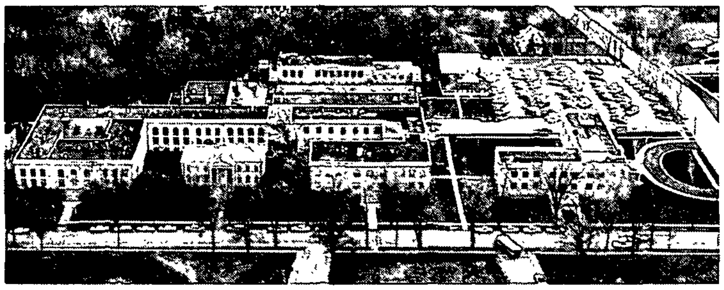
Property of
GEORGIA-PACIFIC CORPORATION
Technical Information Center
Atlanta, Georgia

172



THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

IPC TECHNICAL PAPER SERIES
NUMBER 172

MATHEMATICAL MODELS OF CANADIAN STANDARD FREENESS (CSF) AND SCHOPPER-RIEGLER FREENESS (SR)

P. C. SWODZINSKI AND M. R. DOSHI

MAY, 1986

MATHEMATICAL MODELS OF CANADIAN STANDARD FREENESS (CSF) AND SCHOPPER-RIEGLER FREENESS (SR)

P. C. Swodzinski
Assoc. Control Engineer,
Honeywell, Inc.,
16404 N. Black
Canyon Hwy.,
Phoenix, AZ 85023

M. R. Doshi
The Institute of
Paper Chemistry,
Appleton, WI
54912

ABSTRACT

Theoretical models of Canadian Standard Freeness (CSF) and Schopper Riegler Freeness (SR) were developed using Darcy's law for flow through porous media to determine the theoretical relationship between SR and CSF. SR and CSF tests were run on an unbleached hardwood kraft pulp and an unbleached softwood kraft pulp. Each pulp was tested at several degrees of refining over a range of slurry consistencies.

Results showed that average specific filtration resistance is constant for a given pulp when it is tested at consistencies greater than 0.2%. This provides an indirect verification of the models. It was found from theory and confirmed by experiments that a slurry consistency of 0.95% in an SR test would give freeness values approximately the same as a standard CSF test. Therefore, SR freeness should be measured at 0.95% consistency in addition to the standard measurement at 0.2% consistency.

INTRODUCTION

Freeness is an empirical measure of the drainage resistance of a pulp slurry. Freeness testing is used to measure the degree of refining and to predict the behavior of stock on a paper machine. Clark (1) and Green (2) have published good summaries of the development of freeness testers.

The first freeness tester was introduced by Klemm in 1907. The device consists of a graduated glass tube with a wire screen and a quick-opening cap. The Klemm sedimentation tester measures the volume of fibers deposited on the wire screen after drainage of a pulp slurry. Klemm used this as a measure of beating degree because he observed that a beaten pulp formed a more compact fiber mat.

Shark pointed out that the Klemm tester did not work well for slow draining stocks. Testing was time consuming and the fiber volume was difficult to measure, since a meniscus is formed at the surface. Shark developed his own device, which was made up of a vertical cylinder with a wire cloth at the bottom. Shark used this apparatus to measure the volume of filtrate flow for given time intervals. Determining an endpoint was a problem with sedimentation testers.

In using the Shark tester, Schopper and Riegler noted that all pulps had a very rapid initial discharge of filtrate followed by a rapid drop in flow rate. They also observed that free pulps discharged over half of their original slurry volume during this sudden rush. Based on this observation, Schopper and Riegler developed a freeness tester in 1913. The device has a chamber with a wire screen through which filtrate can drain. The filtrate is discharged into a cone with a larger discharge orifice located slightly above a smaller discharge orifice. The sudden rush of filtrate from free pulps would discharge from both orifices. The rush of filtrate from slow pulps would discharge mostly through the lower orifice. The volume of filtrate which drained through the upper orifice became the measure of pulp freeness. This was the first device to use the "divided-funnel principle" to measure pulp freeness.

The Schopper-Riegler concept was used to design several other freeness testers. In 1915, Green built a device similar to the Schopper-Riegler device. The Canadian Forest Products laboratory devised a tester similar to Green's tester. In 1925, this was modified by Campbell and became the Canadian standard freeness tester.

In 1929, Williams introduced a freeness apparatus similar to the early sedimentation testers. This device measured the time required to drain a 1000 mL pulp slurry of 0.3% consistency. This device suffered from the same shortcoming of the first sedimentation testers in determining endpoint.

Although many newer methods have been devised to measure freeness, Canadian standard freeness and Schopper-Riegler freeness remain the two most commonly used tests. As a measure of beating degree, freeness remains an empirical measurement, since one measurement cannot accurately describe all the changes in fiber properties which occur during refining.

Freeness has also been used to predict resulting paper properties. Originally, it was developed for groundwood pulps. The literature shows that some correlation between sheet properties and freeness exists for groundwood pulps (3). Campbell stated that freeness should not be used for chemical pulps. Chemical pulps having the same freeness as mechanical pulps retain more water than mechanical pulps. Although no good correlation between freeness and paper properties has been shown to exist for chemical pulps, it has found widespread use for this purpose. Freeness gradually was adopted for use with chemical pulps due to its simplicity and reproducibility.

El-Hosseiny and Yan (4) developed a mathematical model for CSF by applying filtration theory. They derived an equation for CSF in terms of two external pulp properties (slurry consistency and water viscosity) and one intrinsic pulp property (pulp average specific filtration resistance). Theoretically, average specific filtration resistance should be a good indicator of the drainage resistance of a pulp.

Objectives of this study are to

1. Develop El-Hosseiny and Yan's model for CSF in more generalized form.

2. Develop a similar model for SR.

Property of
GEORGIA-PACIFIC CORPORATION
Technical Information Center
Atlanta, Georgia

3. Determine the theoretical relationship between CSF and SR.

4. Provide experimental evidence to support the applicability of the models.

CSF Model

One must consider qualitatively what is occurring in the CSF test. Initially, the rate of drainage from the CSF chamber is greater than the combined flow rate from the overflow spout and the bottom orifice. The cone volume between the bottom orifice and the overflow spout fills almost instantly, and the level in the cone rises above the overflow spout. Eventually, the drainage rate decreases. At some point, the rate of drainage will equal the rate of discharge from the cone. The level in the cone will begin to drop until it reaches the side orifice level. The fluid level will stay at this point until the drainage rate equals the flow rate through the bottom orifice. Then, the fluid level will drop until all the fluid has flowed out of the funnel.

A mathematical model of CSF was developed by El-Hosseiny and Yan (4). However, their final equation is unnecessarily complicated, as will be shown later. Referring to Fig. 1:

$$\int_0^t Q_T\,dt = \int_0^t (Q_1 + Q_2)\,dt + V_c \qquad (1)$$

The CSF value is defined as the volume of water collected from the side orifice. If t_1 is the time necessary for flow through the side orifice to cease ($t = t_1$, $Q_2 = 0$, $Q_1 = Q_T$), CSF can be mathematically defined as

$$CSF = \int_0^{t_1} Q_2\,dt = \int_0^{t_1} (Q_T - Q_1)\,dt - V_c \qquad (2)$$

If the volume of filtrate flowing out of the drainage chamber in time, t_1, is denoted by V_1, then V_1 can be expressed as:

$$V_1 = \int_0^{t_1} Q_T\,dt \qquad (3)$$

Assuming that Q_1 is constant, Eq. [2] can be written as:

$$CSF = V_1 - Q_1 t_1 - V_c \qquad (4)$$

Darcy's law can be used to obtain expressions for V_1 and t_1. Substituting these expressions into Eq. [4] will give the generalized form of El-Hosseiny and Yan's equation in terms of C_o, μ, and R_f.

One can express the pressure drop, ΔP, as

$$\Delta P = \rho g h = \rho g \left(\frac{V_o - V}{A}\right) \qquad (5)$$

Darcy's law can now be written as:

$$Q = \frac{dV}{dt} = \frac{(V_o - V)\rho g}{\mu(R_s + R_f C_o V/A)} \qquad (6)$$

If one separates variables and integrates this equation from zero to t_1, which corresponds to $V = 0$ to $V = V_1$, one gets the expression for t_1:

$$t_1 = \frac{\mu}{\rho g}\left[\left(R_s + \frac{R_f C_o V_o}{A}\right) \ln\left(\frac{V_o}{V_o - V_1}\right) - \frac{R_f C_o V_1}{A}\right] \qquad (7)$$

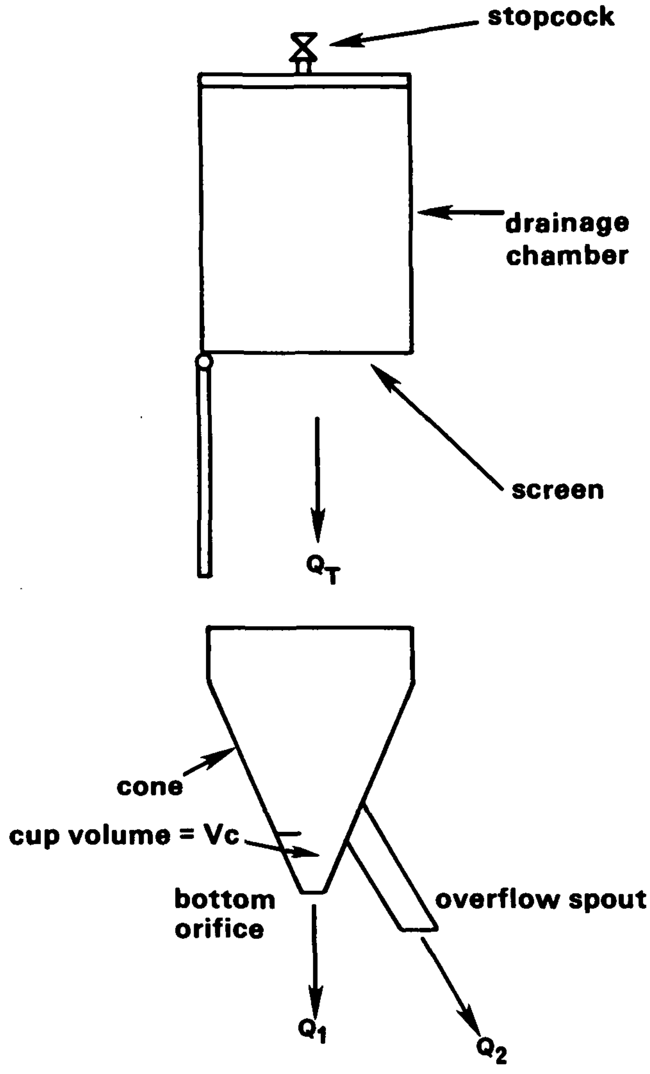


Fig. 1 Schematic diagram of the CSF device.

At $t = t_1$, the flowrate of filtrate from the CSF chamber equals the flowrate out of the bottom orifice:

$$\left.\frac{dV}{dt}\right|_{t_1} = Q_1(t_1) = Q_T(t_1) = \text{constant}$$

2

This constant flowrate will be designated Q_{10}. Substituting $V = V_1$ into Eq. [6] and solving for V_1 gives

$$V_1 = \frac{V_o \rho g - Q_{10} R_s \mu}{\frac{Q_{10} R_f C_o \mu}{A} + \rho g} \tag{8}$$

Assuming that the screen resistance, R_s, is equal to zero, Eq. [7] and [8] become

$$t_1 = \frac{\mu R_f C_o}{\rho g A}\left[V_o \ln\left(\frac{V_o}{V_o - V_1}\right) - V_1 \right] \tag{9}$$

$$V_1 = \frac{\rho g V_o A}{\mu R_f C_o Q_{10} + \rho g A} \tag{10}$$

Combining Eq. [4], [9], and [10] gives El-Hosseiny and Yan's equation for CSF in generalized form:

$$CSF = (V_o - V_c) - Y\left[\ln\left(\frac{V_o}{Y} + 1\right)\right] \tag{11}$$

where:

$$Y = \frac{Q_{10} V_o C_o \mu R_f}{\rho g A}$$

The constant values for the standard CSF unit are

V_o = 1000 mL

V_c = 23.5 mL

A = 81.073 cm^2

ρ = 1.0 g/cm^3

g = 980 cm/s^2

μ = 0.01 g/cm-sec

The form of Eq. [11] presented by El-Hosseiny and Yan is

$$CSF = \frac{10^7}{10^4 + 1.11 C_o \mu R_f} + \frac{1.11 C_o \mu R_f}{10^4} \times \left[\frac{10^7}{10^4 + 1.11 C_o \mu R_f} + 1000 \ln\left(1000 - \frac{10^7}{10^4 + 1.11 C_o \mu R_f}\right) - 6907.76 \right] - 23.5 \tag{12}$$

Equations [11] and [12] are identical as shown by Boyd (5) and Swodzinski (6).

Two key assumptions made here are that Q_{10} is constant and R_s is negligible. Walsh (7) found these to be good assumptions. He determined that bottom orifice flow rate, Q_{10}, increased linearly with total flow rate. When El-Hosseiny and Yan's equation is altered to account for this, the specific filtration resistance values change insignificantly. Also, Walsh determined screen resistance using El-Hosseiny and Yan's equation and found it to be several orders of magnitude lower than the specific filtration resistance of the fibers.

SR Model

A model analagous to the CSF model can be derived for Schopper-Riegler freeness. The SR model is different due to the construction of the apparatus. The SR tester consists of three distinct regions due to changes in diameter (see Fig. 2). There will be three sets of equations corresponding to each section. The set which is applicable will depend on the fluid height in the chamber, h, when $t = t_1$.

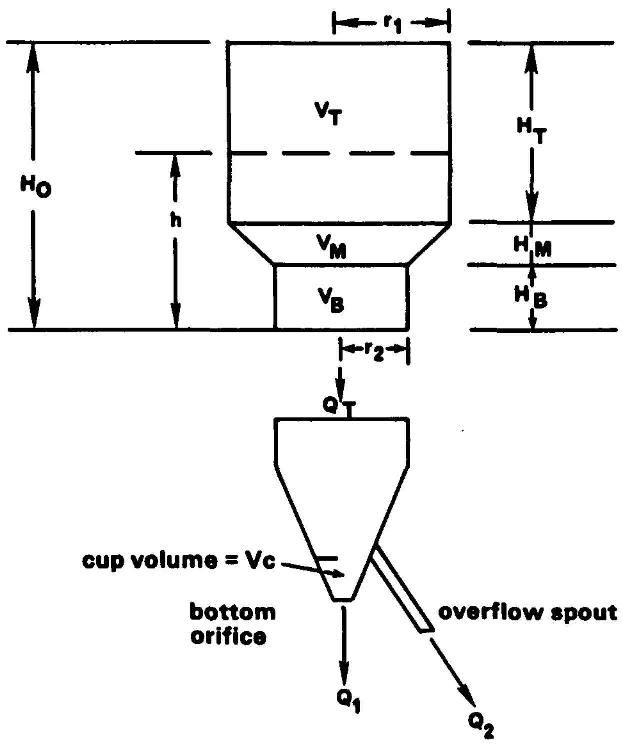


Fig. 2 Schematic diagram of the SR device.

Upper Region

As in the CSF model, one must find expressions for t_1 and V_1 to develop an equation for the SR value. If the fluid level is located in the top region, it follows that

$$h = H_o - V/A_1 \tag{13}$$

The analysis of the upper region of the SR chamber becomes similar to that for the CSF chamber. Darcy's law takes the form:

3

$$Q_T = \frac{dV}{dt} = \frac{A_2 g (H_o - V/A_1)\rho}{\mu \left(R_s + \frac{R_f C_o V}{A_2}\right)} \tag{14}$$

To obtain an expression for t_1, one must separate variables in Eq. [30] and integrate. Solving for t_1 and neglecting R_s results in

$$t_1 = \frac{\mu}{\rho g A_2}\left[\frac{A_1^2 R_f C_o H_o}{A_2} \ln\left(\frac{A_1 H_o}{A_1 H_o - V_1}\right) - \frac{A_1 R_f C_o V_1}{A_2}\right] \tag{15}$$

To derive an equation for V_1, one must substitute $V = V_1$ into Eq. [14], neglect R_s, and assign $Q_T = Q_{10}$:

$$V_1 = \frac{A_1 A_2^2 \rho g H_o}{\mu A_1 Q_{10} R_f C_o + A_2^2 \rho g} \tag{16}$$

The equation for SR can be derived in the same manner as Eq. [4].

$$SR = V_1 - Q_{10} t_1 - V_c \tag{17}$$

Equation [17] will apply regardless of the region that the fluid level is in at t_1.

Middle Region

Modeling becomes difficult in the middle region because the cross-sectional area is changing as the fluid height changes. Referring to Fig. 3, the fluid height at any point in this section can be expressed as

$$h = H_B + r - r_2 \tag{18}$$

The volume of fluid in the middle section can be derived using the formula for the volume of a truncated cone:

$$V_o - V - V_B = \frac{\pi\,(r^3 - r_2^3)}{3} \tag{19}$$

Volumetric flow rate can be expressed as

$$Q = \frac{dV}{dt} = \frac{dV}{dr} \cdot \frac{dr}{dt} \tag{20}$$

Integrated form of the Darcy's law becomes

$$\frac{A_2 \rho g}{\mu} \int_{t_T}^{t_1} dt = \int_{r_1}^{r} \left(\frac{K_1 r^5 - K_2 r^2}{K_3 + r}\right) dr \tag{21}$$

where

t_T = time required for fluid level to reach the top of the middle section (sec)

$$K_1 = \frac{R_f C_o}{A_2} \cdot \frac{\pi^2}{3} \tag{22}$$

$$K_2 = \frac{\pi R_f C_o}{A_2} \left(V_o - V_B + \frac{\pi}{3} r_2^3\right) \tag{23}$$

$$K_3 = H_B - r_2 \tag{24}$$

Integrating both sides gives:

$$\begin{aligned} t_1 = t_T + \frac{\mu}{A_2 \rho g} \Big\{ & K_1 \big[(K_3 + r)^5/5 \\ & - 5K_3 (K_3 + r)^4/4 + 10K_3^2 (K_3 + r)^3/3 \\ & - 5K_3^3 (K_3 + r)^2 + 5K_3^4 (K_3 + r) \\ & - K_3^5 \ln (K_3 + r)\big] - K_2 \big[(K_3 + r)^2/2 \\ & - 2K_3 (K_3 + r) + K_3^2 \ln (K_3 + r)\big]\Big\}_{r_1}^{r} \end{aligned} \tag{25}$$

An expression for V_1 can be found to be:

$$V_1 = \frac{A_2^2 \rho g h}{Q_{10} R_f C_o \mu} \tag{26}$$

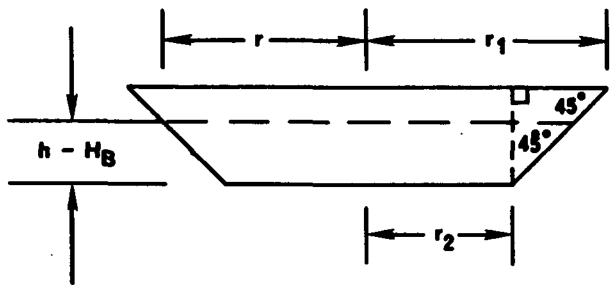


Fig. 3 Geometry of the conical section of the SR chamber.

Lower Region

The key equations which apply to this region of the SR chamber will be summarized briefly. They are derived using concepts previously discussed in this paper.

$$h = \left(\frac{V_o - V}{A_2}\right) \tag{27}$$

$$t_1 = t_T + t_M + \left(\frac{\mu R_f C_o}{\rho g A_2}\right)\left[V_o \ln\left(\frac{V_o - V_2}{V_o - V_1}\right) + (V_2 - V_1)\right] \tag{28}$$

The expressions for V_1 and SR will be the same as those for the middle region. The constant values needed to use these equations are

V_o = 1000 mL

V_c = 8.0 mL/sec

Q_{10} = 3.0 mL/sec

A_1 = 147.4 cm^2

A_2 = 100 cm^2

H_o = 7.8 cm

H_B = 2.5 cm

H_M = 1.205 cm

H_T = 4.09 cm

V_B = 250.0 cm^3

V_M = 147.0 cm^3

V_T = 603. 0 cm^3

V_2 = 750.0 cm^3

r_2 = 5.64 cm

r_1 = 6.85 cm

Experiments

Unbleached softwood and hardwood pulps (never dried) were separately refined in the Valley beater using TAPPI Standard T205 os-71 (for unrefined pulps). The CSF and SR measuring devices were calibrated according to the procedures specified in TAPPI Standard T227 os-58 and Scandinavian Pulp, Paper and Board standard, SCAN-M3:65. Consistency, temperature, and freeness values - CSF and SR, were measured for each pulp sample. Measurements of freeness were repeated four times. To test the applicability of the equations developed in the previous Section, measurements were carried out at six different consistencies, including the standard value of 0.3% for CSF and 0.2% for SR. The measured CSF and SR values can be used to calculate specific filtration resistance, R_f, from the theory.

RESULTS AND DISCUSSION

Specific Filtration Resistance

The specific filtration resistance, R_f, calculated from a measured freeness value and theory, is expected to be constant for a given pulp, since pressure changes are relatively small. Results of Table 1 show that for slurry consistencies of 0.2% or greater, R_f values obtained from CSF were relatively constant. R_f data acquired from SR testing are shown in Table 2. These data also show that R_f values are essentially constant for slurry consistencies of 0.2% or greater.

If the Darcy's law is applicable to SR and CSF, one would anticipate that the R_f values obtained from both models should be approximately equal. Tables 1 and 2 show that this is true for C_o greater than 0.2% for all the pulps tested except one. The R_f values from CSF testing are significantly less than those from SR testing for unbleached, unrefined softwood kraft. This pulp has the highest freeness of all these pulps. Darcy's law may not apply for very high freeness pulps.

Empirical Relationship between CSF and SR

The empirical relationship between a standard CSF test and a standard SR test has been reported in the literature (8-10). These data from several different sources are shown in Fig. 4. Although some difference exists, the empirical relationship between CSF and SR is roughly the same for all the data in Fig. 4. Any shifts in the empirical curves are probably due to the effect of the electrolyte concentration of the water and its effect on the swelling characteristics of fibers. Figure 4 shows that SR data and CSF data from this study have about the same empirical relationship as the previous data.

Theoretical Relationship between CSF and SR

By equating the specific filtration resistance, R_f, a theoretical relationship between CSF and SR can be obtained. The theoretical CSF vs. SR curve compares well with the empirical data of Fig. 4, which is further evidence for the validity of the CSF and SR models.

In Fig. 5, CSF (C_o = 0.3%) and SR (C_o = 0.2%) are plotted vs. R_f. Assuming that the difference between the curves is due to the initial slurry consistency, the SR curve at some consistency should coincide with the CSF (C_o = 0.3%) curve. It was determined by trial-and-error that the SR curve approximates the standard CSF curve for an initial slurry consistency of 0.95%. This is shown in Fig. 6.

Based on Fig. 6, a CSF test using 3 g of pulp per liter should give the same value in milliliters as an SR test which uses 9.5 g of pulp per liter. The data in Table 3 show that this is approximately true. This result suggests that it may be better to make 9.5 g of pulp a requirement for a standard SR test. Also, this result further supports the applicability of the SR and CSF models developed in this study.

Drainage Time

Theoretical values for t_1, time required for the filtrate flow rate to approach the bottom orifice flow rate, are plotted vs. CSF in Fig. 7. Although no experimental evidence is available to support the bell-shaped curves predicted by the CSF and SR models, they may be explained intuitively.

At low freenesses, the flow of filtrate is very slow. Therefore, t_1 will be small. At high freenesses, the flow of filtrate is fast. Again, the filtrate flow rate quickly approaches the bottom orifice flow rate and t_1 is small.

Consistency and Temperature Corrections

El-Hosseiny and Yan assumed that the effect of temperature on CSF is entirely due to the effect of

5

Table 1 Calculated specific filtration resistance

Pulp	Consistency, %	CSF,[a] mL	Specific Filtration Resistance,[b] cm/g x 10^{-8}
Unbleached	0.554	586±10	0.381
Unrefined	0.446	632± 8	0.375
Softwood kraft	0.417	630± 0	0.400 Average = 0.406±0.027
	0.285	686± 2	0.438
	0.220	725± 4	0.438
	0.110	777± 4	0.612
Unbleached	0.613	290± 4	1.42
Refined	0.426	358±10	1.46
Softwood kraft	0.392	394± 7	1.34 Average = 1.40±0.04
(refined for	0.303	444± 4	1.38
45 minutes)	0.202	528± 8	1.39
	0.102	661± 2	1.40
Unbleached	0.587	126± 4	4.12
Refined	0.433	185± 4	3.65
Softwood kraft	0.400	190± 9	3.82 Average = 3.87±0.17
(refined for	0.308	230± 8	3.90
70 minutes)	0.197	304± 7	4.11
	0.083	452± 6	4.82
Unbleached	0.573	59± 2	8.50
Refined	0.466	72± 2	8.79
Softwood kraft	0.417	88± 2	8.30 Average = 8.53±0.023
(refined for	0.322	115± 4	8.26
90 minutes)	0.213	160± 0	8.79
	0.123	274± 4	7.69
Unbleached	0.638	384± 4	0.862
Unrefined	0.456	449± 5	0.890
Hardwood kraft	0.410	479± 2	0.863 Average = 0.923±0.064
	0.294	518± 4	1.00
	0.222	575± 5	1.00
	0.100	664± 4	1.40
Unbleached	0.604	214± 8	2.19
Refined	0.471	275± 5	1.99
Hardwood kraft	0.405	300± 0	2.04 Average = 2.14±0.13
(refined for	0.271	355± 5	2.32
35 minutes)	0.188	422± 6	2.44
	0.110	548± 8	2.32
Unbleached	0.616	129± 2	3.85
Refined	0.456	182± 2	3.52
Hardwood kraft	0.421	200± 0	3.41 Average = 3.64±0.17
(refined for	0.308	239± 5	3.71
60 minutes)	0.182	306±10	4.40
	0.106	438± 4	4.05

[a]Average of four measurements.
[b]Calculated from Eq. [11]. In calculating average resistance, results for consistency less than 0.2% have been disregarded.

6

Table 2 Calculated specific filtration resistance

Pulp	Consistency, %	SR,[a] mL	Specific Filtration Resistance,[b] cm/g x 10^{-8}	
Unbleached	0.554	721±13	0.69	
Unrefined	0.446	766± 4	0.64	
Softwood kraft	0.417	767± 4	0.68	Average = 0.66±0.02
	0.285	824± 5	0.64	
	0.220	851± 6	0.66	
	0.110	905± 8	0.68	
Unbleached	0.613	564± 4	1.39	
Refined	0.426	626± 4	1.50	
Softwood kraft	0.392	654± 2	1.41	Average = 1.42±0.04
(refined for	0.303	704± 4	1.39	
45 minutes)	0.202	769± 5	1.39	
	0.102	866± 2	1.21	
Unbleached	0.587	350± 4	3.68	
Refined	0.433	404± 4	3.90	
Softwood kraft	0.400	418± 2	3.98	Average = 3.80±0.015
(refined for	0.308	504±13	3.62	
70 minutes)	0.197	589± 7	3.89	
	0.083	746± 4	3.90	
Unbleached	0.573	185± 4	8.97	
Refined	0.466	221± 2	8.86	
Softwood kraft	0.417	246± 4	8.62	Average = 8.80±0.11
(refined for	0.322	294± 4	8.79	
90 minutes)	0.213	380± 4	8.77	
	0.123	578± 6	6.54	
Unbleached	0.638	658± 2	0.85	
Unrefined	0.456	719± 2	0.85	
Hardwood kraft	0.410	739± 2	0.84	Average = 0.83±0.04
	0.294	785± 4	0.85	
	0.222	834± 2	0.75	
	0.100	896± 2	0.84	
Unbleached	0.604	476± 4	2.07	
Refined	0.471	548± 4	1.96	
Hardwood kraft	0.405	573± 4	2.04	Average = 2.08±0.11
(refined for	0.271	635± 5	2.25	
35 minutes)	0.188	710± 4	2.18	
	0.110	824± 4	1.67	
Unbleached	0.616	354± 9	3.46	
Refined	0.456	428± 8	3.36	
Hardwood kraft	0.421	454± 4	3.26	Average = 3.38±0.08
(refined for	0.308	516± 4	3.44	
60 minutes)	0.182	608± 4	3.85	
	0.106	752± 4	2.96	

[a]Average of four measurements.
[b]Calculated from theory. In calculating average resistance, results for consistency less than 0.12% have been disregarded.

7

temperature on fluid viscosity. Walsh plotted the correction for CSF at 30°C vs. the CSF at 20°C using (1) TAPPI standard for CSF, (2) El-Hosseiny and Yan's model for $R_s = 0$, and (3) El-Hosseiny and Yan's model for $R_s = 1 \times 10^6$ cm/g. This is shown in Fig. 8. This also resulted in bell-shaped curves with maximums at about the same CSF value as the t_l vs. CSF curve. Comparing Fig. 7 and Fig. 8, CSF corrections for temperature are relatively small when t_l is small. Based on the original assumption, these graphs indicate that the effect of fluid viscosity is small when t_l is small.

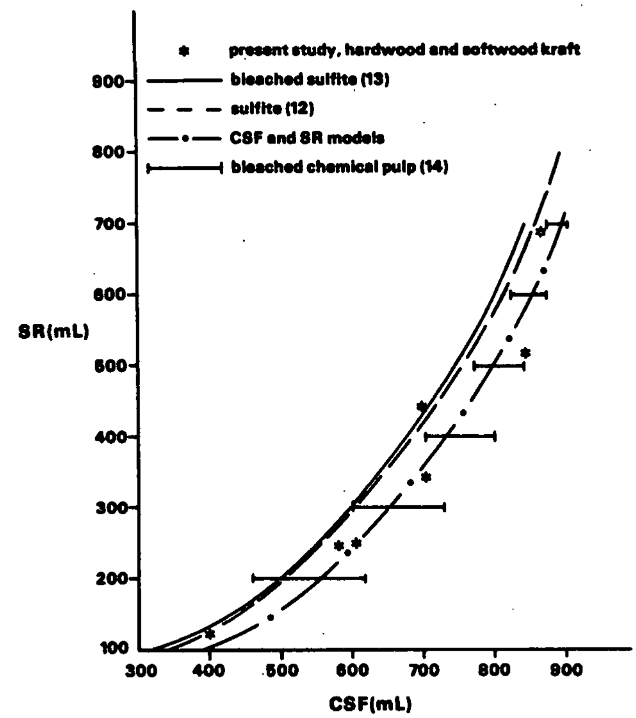


Fig. 4 Theoretical and empirical correlations between CSF and SR.

Standard practice is to measure CSF at 0.3% consistency and 20°C. Theory can be used to calculate corrections to be made if consistency and/or temperature changes from the standard values. These corrections are given in Tables 4 and 5. Similarly corrections for SR measurement at 0.2% consistency are given in Tables 6 and 7 and those at 0.95% consistency are given in Tables 8 and 9.

CONCLUSIONS

1. For consistencies greater than 0.2%, Darcy's law can be used to describe the CSF and SR apparatuses.

2. At low consistencies or very high freeness, Darcy's law may not apply.

3. An SR test using 9.5 g of ovendry pulp per liter yields about the same values as a standard CSF test. 0.95% may be a better consistency for a standard SR test.

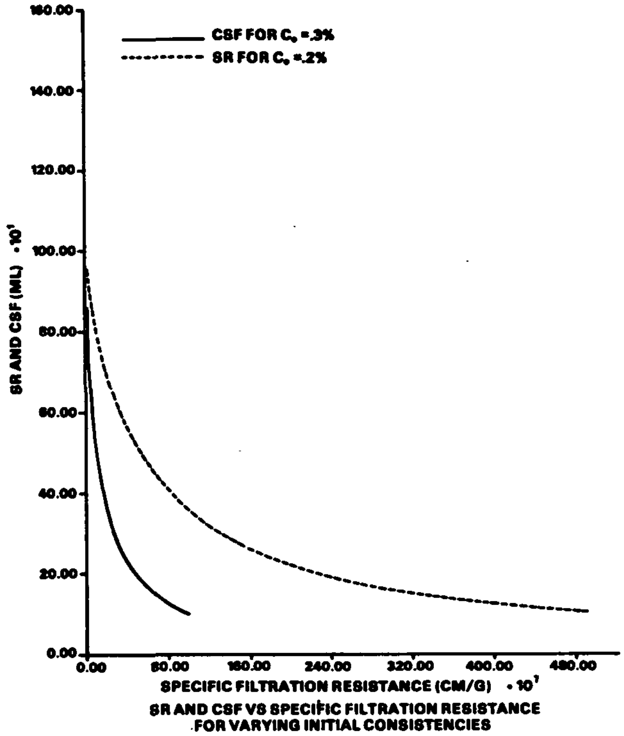


Fig. 5 Relationship between specific filtration resistance, CSF, and SR (2 g).

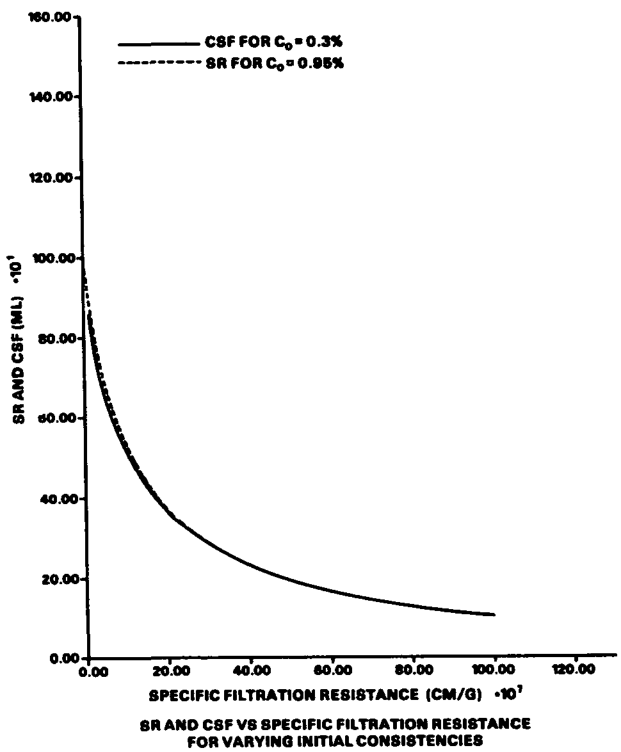


Fig. 6 Relationship between specific filtration resistance, CSF, and SR (9.5 g).

8

Table 3 SR Freeness corrected for initial slurry consistency

Pulp	SR, mL	C, %	Corrected SR for C_o = 0.95%
Unbleached	118	1.02	126
Softwood	225	0.942	224
	425	0.973	430
Unbleached	342	0.957	345
Hardwood	228	0.982	234

COMPARISON OF CSF AND SR AT CORRECTED INITIAL SLURRY CONSISTENCIES

CSF (C = 0.3%)	SR (0.95%)	% Difference
125	126	0.8
245	224	8.6
443	430	2.9
342	345	0.9
250	234	6.4

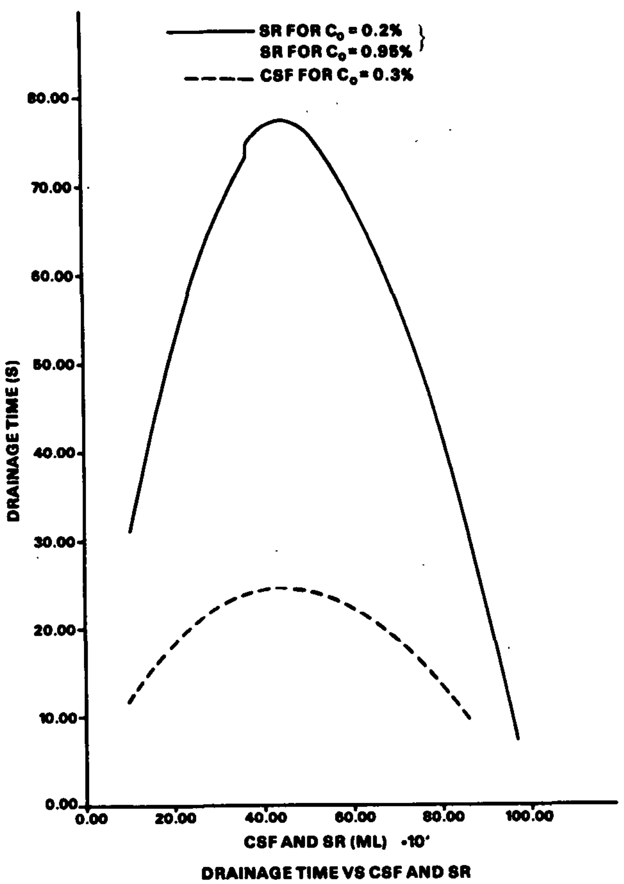


Fig. 7 Drainage time vs. CSF and SR.

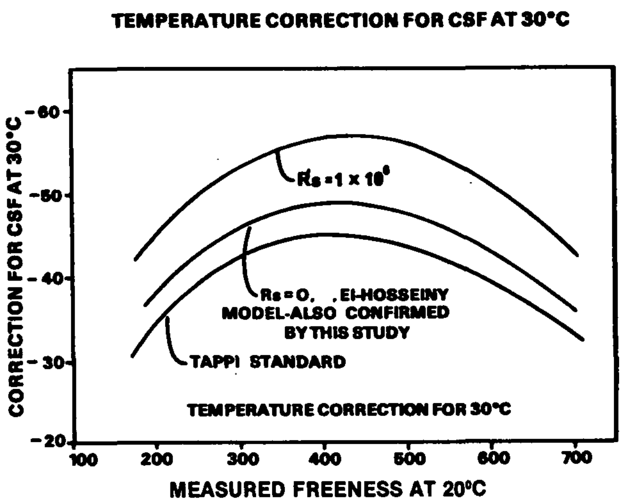


Fig. 8 Temperature correction for CSF at 30°C.

NOMENCLATURE

A = cross-sectional area of bed (cm^2)

A_1 = cross-sectional area of top section of SR chamber (cm^2)

A_2 = cross-sectional area of the bottom region of SR chamber (cm^2)

C_o = initial consistency of slurry (g/cm^3)

g = universal gravitational constant (cm/sec^2)

h = fluid height (cm)

H_B = height of the bottom section of SR chamber (cm)

Table 4 CSF correction for consistency

Freeness ↓ / % C →	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40
30.	-24.0	-20.7	-17.6	-14.8	-12.2	-9.8	-7.6	-5.5	-3.5	-1.7	0.0	1.6	3.1	4.6	5.9	7.2	8.4	9.5	10.6	11.7	12.7
40.	-28.0	-24.1	-20.6	-17.3	-14.3	-11.5	-8.8	-6.4	-4.1	-2.0	0.0	1.9	3.7	5.3	6.9	8.4	9.8	11.2	12.5	13.7	14.9
50.	-31.7	-27.4	-23.4	-19.7	-16.2	-13.0	-10.1	-7.3	-4.7	-2.3	0.0	2.2	4.2	6.1	7.9	9.6	11.3	12.8	14.3	15.7	17.0
60.	-35.4	-30.5	-26.1	-21.9	-18.1	-14.6	-11.3	-8.2	-5.3	-2.6	0.0	2.4	4.7	6.8	8.9	10.8	12.6	14.4	16.0	17.6	19.1
70.	-38.8	-33.5	-28.7	-24.1	-20.0	-16.1	-12.4	-9.0	-5.8	-2.8	0.0	2.7	5.2	7.6	9.8	11.9	14.0	15.9	17.8	19.5	21.2
80.	-42.1	-36.4	-31.1	-26.3	-21.7	-17.5	-13.5	-9.8	-6.4	-3.1	0.0	2.9	5.6	8.3	10.7	13.1	15.3	17.4	19.4	21.3	23.2
90.	-45.3	-39.2	-33.5	-28.3	-23.4	-18.9	-14.6	-10.6	-6.9	-3.3	0.0	3.1	6.1	8.9	11.6	14.1	16.6	18.9	21.0	23.1	25.1
100.	-48.3	-41.8	-35.8	-30.2	-25.0	-20.2	-15.6	-11.4	-7.4	-3.6	0.0	3.4	6.6	9.6	12.5	15.2	17.8	20.3	22.6	24.9	27.0
110.	-51.2	-44.3	-38.0	-32.1	-26.6	-21.4	-16.6	-12.1	-7.8	-3.8	0.0	3.6	7.0	10.2	13.3	16.2	19.0	21.6	24.2	26.6	28.9
120.	-53.9	-46.7	-40.1	-33.9	-28.1	-22.7	-17.6	-12.8	-8.3	-4.0	0.0	3.8	7.4	10.8	14.1	17.2	20.2	23.0	25.7	28.2	30.7
130.	-56.5	-49.0	-42.1	-35.6	-29.5	-23.8	-18.5	-13.5	-8.7	-4.2	0.0	4.0	7.8	11.4	14.9	18.2	21.3	24.3	27.1	29.8	32.5
140.	-59.0	-51.2	-44.0	-37.2	-30.9	-24.9	-19.4	-14.1	-9.1	-4.4	0.0	4.2	8.2	12.0	15.6	19.1	22.4	25.5	28.5	31.4	34.2
150.	-61.3	-53.3	-45.8	-38.8	-32.2	-26.0	-20.2	-14.7	-9.5	-4.6	0.0	4.4	8.6	12.6	16.4	20.0	23.4	26.7	29.9	32.9	35.8
160.	-63.6	-55.3	-47.5	-40.3	-33.4	-27.0	-21.0	-15.3	-9.9	-4.8	0.0	4.6	9.0	13.1	17.1	20.8	24.5	27.9	31.2	34.4	37.4
170.	-65.7	-57.2	-49.2	-41.7	-34.6	-28.0	-21.8	-15.9	-10.3	-5.0	0.0	4.8	9.3	13.6	17.7	21.7	25.4	29.0	32.5	35.8	39.0
180.	-67.7	-58.9	-50.7	-43.0	-35.8	-29.0	-22.5	-16.4	-10.7	-5.2	0.0	4.9	9.6	14.1	18.4	22.5	26.4	30.1	33.7	37.2	40.5
190.	-69.6	-60.6	-52.2	-44.3	-36.9	-29.8	-23.2	-16.9	-11.0	-5.4	0.0	5.1	10.0	14.6	19.0	23.3	27.3	31.2	34.9	38.5	41.9
200.	-71.4	-62.2	-53.6	-45.5	-37.9	-30.7	-23.9	-17.4	-11.3	-5.5	0.0	5.3	10.3	15.1	19.6	24.0	28.2	32.2	36.1	39.8	43.3
210.	-73.1	-63.7	-54.9	-46.7	-38.9	-31.5	-24.5	-17.9	-11.6	-5.7	0.0	5.4	10.6	15.5	20.2	24.7	29.0	33.2	37.2	41.0	44.7
220.	-74.6	-65.1	-56.2	-47.7	-39.8	-32.2	-25.1	-18.4	-11.9	-5.8	0.0	5.6	10.8	15.9	20.8	25.4	29.9	34.1	38.2	42.2	46.0
230.	-76.1	-66.4	-57.3	-48.7	-40.6	-33.0	-25.7	-18.8	-12.2	-6.0	0.0	5.7	11.1	16.3	21.3	26.1	30.6	35.0	39.2	43.3	47.2
240.	-77.5	-67.7	-58.4	-49.7	-41.4	-33.6	-26.2	-19.2	-12.5	-6.1	0.0	5.8	11.4	16.7	21.8	26.7	31.4	35.9	40.2	44.4	48.4
250.	-78.7	-68.8	-59.4	-50.6	-42.2	-34.3	-26.7	-19.6	-12.7	-6.2	0.0	5.9	11.6	17.1	22.3	27.3	32.1	36.7	41.1	45.4	49.5
260.	-79.9	-69.9	-60.4	-51.4	-42.9	-34.9	-27.2	-19.9	-13.0	-6.3	0.0	6.1	11.9	17.4	22.7	27.9	32.8	37.5	42.0	46.4	50.6
270.	-81.0	-70.9	-61.3	-52.2	-43.6	-35.4	-27.7	-20.3	-13.2	-6.5	0.0	6.2	12.1	17.7	23.2	28.4	33.4	38.2	42.9	47.4	51.7
280.	-82.0	-71.8	-62.1	-52.9	-44.2	-35.9	-28.1	-20.6	-13.4	-6.6	0.0	6.3	12.3	18.0	23.6	28.9	34.0	38.9	43.7	48.3	52.7
290.	-82.9	-72.6	-62.8	-53.6	-44.8	-36.4	-28.4	-20.8	-13.6	-6.6	0.0	6.4	12.5	18.3	24.0	29.4	34.6	39.6	44.5	49.1	53.6
300.	-83.7	-73.3	-63.5	-54.2	-45.3	-36.9	-28.8	-21.1	-13.8	-6.7	0.0	6.5	12.7	18.6	24.3	29.8	35.1	40.2	45.2	49.9	54.5
310.	-84.4	-74.0	-64.1	-54.7	-45.8	-37.3	-29.1	-21.4	-13.9	-6.8	0.0	6.5	12.8	18.9	24.7	30.3	35.6	40.8	45.9	50.7	55.4
320.	-85.1	-74.6	-64.7	-55.2	-46.2	-37.6	-29.4	-21.6	-14.1	-6.9	0.0	6.6	13.0	19.1	25.0	30.7	36.1	41.4	46.5	51.4	56.2
330.	-85.6	-75.1	-65.2	-55.7	-46.6	-38.0	-29.7	-21.8	-14.2	-7.0	0.0	6.7	13.1	19.3	25.3	31.0	36.6	41.9	47.1	52.1	56.9
340.	-86.1	-75.6	-65.6	-56.0	-46.9	-38.3	-29.9	-22.0	-14.3	-7.0	0.0	6.8	13.3	19.5	25.5	31.4	37.0	42.4	47.6	52.7	57.6
350.	-86.5	-76.0	-66.0	-56.4	-47.2	-38.5	-30.2	-22.1	-14.5	-7.1	0.0	6.8	13.4	19.7	25.8	31.7	37.4	42.8	48.1	53.3	58.3
360.	-86.9	-76.3	-66.3	-56.7	-47.5	-38.7	-30.3	-22.3	-14.6	-7.1	0.0	6.9	13.5	19.9	26.0	32.0	37.7	43.3	48.6	53.8	58.8
370.	-87.1	-76.6	-66.5	-56.9	-47.7	-38.9	-30.5	-22.4	-14.6	-7.2	0.0	6.9	13.6	20.0	26.2	32.2	38.0	43.6	49.0	54.3	59.4
380.	-87.3	-76.8	-66.7	-57.1	-47.9	-39.1	-30.6	-22.5	-14.7	-7.2	0.0	7.0	13.7	20.1	26.4	32.5	38.3	44.0	49.4	54.7	59.9
390.	-87.4	-76.9	-66.8	-57.2	-48.0	-39.2	-30.7	-22.6	-14.8	-7.3	0.0	7.0	13.7	20.3	26.6	32.7	38.5	44.3	49.8	55.1	60.3
400.	-87.4	-77.0	-66.9	-57.3	-48.1	-39.3	-30.8	-22.7	-14.8	-7.3	0.0	7.0	13.8	20.4	26.7	32.8	38.8	44.5	50.1	55.5	60.7
410.	-87.4	-77.0	-67.0	-57.4	-48.2	-39.4	-30.9	-22.7	-14.9	-7.3	0.0	7.0	13.9	20.4	26.8	33.0	38.9	44.7	50.3	55.8	61.1
420.	-87.3	-76.9	-66.9	-57.4	-48.2	-39.4	-30.9	-22.8	-14.9	-7.3	0.0	7.1	13.9	20.5	26.9	33.1	39.1	44.9	50.6	56.0	61.4
430.	-87.2	-76.8	-66.9	-57.3	-48.2	-39.4	-30.9	-22.8	-14.9	-7.3	0.0	7.1	13.9	20.6	27.0	33.2	39.2	45.1	50.7	56.3	61.6
440.	-86.9	-76.6	-66.7	-57.3	-48.1	-39.4	-30.9	-22.8	-14.9	-7.3	0.0	7.1	13.9	20.6	27.0	33.3	39.3	45.2	50.9	56.4	61.8
450.	-86.6	-76.4	-66.6	-57.1	-48.0	-39.3	-30.9	-22.8	-14.9	-7.3	0.0	7.1	13.9	20.6	27.0	33.3	39.4	45.3	51.0	56.5	62.0
460.	-86.3	-76.1	-66.3	-57.0	-47.9	-39.2	-30.8	-22.7	-14.9	-7.3	0.0	7.1	13.9	20.6	27.1	33.3	39.4	45.3	51.0	56.6	62.1
470.	-85.9	-75.8	-66.1	-56.7	-47.8	-39.1	-30.7	-22.7	-14.9	-7.3	0.0	7.1	13.9	20.6	27.0	33.3	39.4	45.3	51.1	56.7	62.1
480.	-85.4	-75.4	-65.7	-56.5	-47.5	-38.9	-30.6	-22.6	-14.8	-7.3	0.0	7.1	13.9	20.5	27.0	33.3	39.4	45.3	51.0	56.7	62.1
490.	-84.8	-74.9	-65.4	-56.2	-47.3	-38.8	-30.5	-22.5	-14.8	-7.3	0.0	7.0	13.9	20.5	26.9	33.2	39.3	45.2	51.0	56.6	62.1
500.	-84.2	-74.4	-65.0	-55.8	-47.0	-38.5	-30.3	-22.4	-14.7	-7.2	0.0	7.0	13.8	20.4	26.9	33.1	39.2	45.1	50.9	56.5	62.0
510.	-83.6	-73.9	-64.5	-55.5	-46.7	-38.3	-30.2	-22.3	-14.6	-7.2	0.0	7.0	13.8	20.4	26.8	33.0	39.1	45.0	50.7	56.4	61.8
520.	-82.9	-73.3	-64.0	-55.0	-46.4	-38.0	-30.0	-22.1	-14.5	-7.2	0.0	6.9	13.7	20.3	26.6	32.9	38.9	44.8	50.6	56.2	61.6
530.	-82.1	-72.6	-63.4	-54.6	-46.0	-37.7	-29.7	-22.0	-14.4	-7.1	0.0	6.9	13.6	20.1	26.5	32.7	38.7	44.6	50.3	55.9	61.4
540.	-81.3	-71.9	-62.8	-54.1	-45.6	-37.4	-29.5	-21.8	-14.3	-7.1	0.0	6.9	13.5	20.0	26.3	32.5	38.5	44.4	50.1	55.7	61.1
550.	-80.4	-71.1	-62.2	-53.6	-45.2	-37.1	-29.2	-21.6	-14.2	-7.0	0.0	6.8	13.4	19.9	26.2	32.3	38.3	44.1	49.8	55.3	60.8
560.	-79.4	-70.3	-61.5	-53.0	-44.7	-36.7	-28.9	-21.4	-14.1	-6.9	0.0	6.7	13.3	19.7	26.0	32.0	38.0	43.8	49.4	55.0	60.4
570.	-78.5	-69.5	-60.8	-52.4	-44.2	-36.3	-28.6	-21.2	-13.9	-6.9	0.0	6.7	13.2	19.5	25.7	31.8	37.7	43.4	49.1	54.6	59.9
580.	-77.4	-68.6	-60.0	-51.7	-43.7	-35.9	-28.3	-20.9	-13.8	-6.8	0.0	6.6	13.1	19.4	25.5	31.5	37.3	43.1	48.6	54.1	59.4
590.	-76.3	-67.6	-59.2	-51.1	-43.1	-35.4	-28.0	-20.7	-13.6	-6.7	0.0	6.5	12.9	19.2	25.2	31.2	37.0	42.6	48.2	53.6	58.9
600.	-75.2	-66.7	-58.4	-50.3	-42.5	-35.0	-27.6	-20.4	-13.4	-6.6	0.0	6.5	12.8	18.9	25.0	30.8	36.6	42.2	47.7	53.1	58.3
610.	-74.0	-65.6	-57.5	-49.6	-41.9	-34.5	-27.2	-20.1	-13.3	-6.5	0.0	6.4	12.6	18.7	24.7	30.5	36.2	41.7	47.2	52.5	57.7
620.	-72.8	-64.5	-56.6	-48.8	-41.3	-33.9	-26.8	-19.8	-13.1	-6.5	0.0	6.3	12.4	18.5	24.3	30.1	35.7	41.2	46.6	51.9	57.0
630.	-71.5	-63.4	-55.6	-48.0	-40.6	-33.4	-26.4	-19.5	-12.9	-6.4	0.0	6.2	12.3	18.2	24.0	29.7	35.2	40.6	46.0	51.2	56.3
640.	-70.2	-62.3	-54.6	-47.1	-39.9	-32.8	-25.9	-19.2	-12.6	-6.2	0.0	6.1	12.1	17.9	23.6	29.2	34.7	40.1	45.3	50.5	55.5
650.	-68.8	-61.1	-53.6	-46.3	-39.1	-32.2	-25.5	-18.9	-12.4	-6.1	0.0	6.0	11.9	17.6	23.2	28.8	34.2	39.4	44.6	49.7	54.7
660.	-67.4	-59.8	-52.5	-45.3	-38.4	-31.6	-25.0	-18.5	-12.2	-6.0	0.0	5.9	11.7	17.3	22.9	28.3	33.6	38.8	43.9	48.9	53.8
670.	-65.9	-58.5	-51.4	-44.4	-37.6	-30.9	-24.5	-18.1	-12.0	-5.9	0.0	5.8	11.4	17.0	22.4	27.8	33.0	38.1	43.1	48.1	52.9
680.	-64.4	-57.2	-50.2	-43.4	-36.8	-30.3	-23.9	-17.8	-11.7	-5.8	0.0	5.7	11.2	16.7	22.0	27.2	32.4	37.4	42.3	47.2	51.9
690.	-62.8	-55.8	-49.0	-42.4	-35.9	-29.6	-23.4	-17.4	-11.4	-5.7	0.0	5.5	11.0	16.3	21.5	26.7	31.7	36.6	41.5	46.2	50.9
700.	-61.2	-54.4	-47.8	-41.3	-35.0	-28.9	-22.8	-17.0	-11.2	-5.5	0.0	5.4	10.7	15.9	21.1	26.1	31.0	35.8	40.6	45.3	49.9

10

Table 5 CSF Correction for temperature

Temp. ↓ / Freeness →	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
30.	11.8	10.7	9.5	8.4	7.2	6.0	4.8	3.7	2.4	1.2	0.0	-1.2	-2.5	-3.7	-4.9	-6.2	-7.4	-8.7	-10.0	-11.3	-12.5
40.	13.9	12.5	11.2	9.8	8.4	7.1	5.7	4.3	2.8	1.4	0.0	-1.4	-2.9	-4.3	-5.8	-7.2	-8.7	-10.2	-11.6	-13.1	-14.6
50.	15.9	14.4	12.8	11.2	9.6	8.1	6.5	4.9	3.2	1.6	0.0	-1.6	-3.3	-4.9	-6.6	-8.2	-9.9	-11.6	-13.3	-14.9	-16.6
60.	17.8	16.1	14.3	12.6	10.8	9.1	7.3	5.5	3.6	1.8	0.0	-1.8	-3.7	-5.5	-7.4	-9.2	-11.1	-12.9	-14.8	-16.7	-18.6
70.	19.7	17.8	15.9	14.0	11.9	10.0	8.0	6.1	4.0	2.0	0.0	-2.0	-4.0	-6.1	-8.1	-10.2	-12.2	-14.3	-16.3	-18.4	-20.5
80.	21.6	19.5	17.4	15.3	13.1	11.0	8.8	6.6	4.4	2.2	0.0	-2.2	-4.4	-6.6	-8.8	-11.1	-13.3	-15.5	-17.8	-20.0	-22.3
90.	23.4	21.2	18.8	16.5	14.1	11.9	9.5	7.2	4.7	2.4	0.0	-2.4	-4.8	-7.1	-9.5	-11.9	-14.3	-16.7	-19.2	-21.6	-24.0
100.	25.2	22.8	20.2	17.8	15.2	12.7	10.2	7.7	5.1	2.5	0.0	-2.6	-5.1	-7.7	-10.2	-12.8	-15.4	-17.9	-20.5	-23.1	-25.7
110.	26.9	24.3	21.6	19.0	16.2	13.6	10.9	8.2	5.4	2.7	0.0	-2.7	-5.4	-8.2	-10.9	-13.6	-16.3	-19.0	-21.8	-24.5	-27.2
120.	28.6	25.8	22.9	20.1	17.2	14.4	11.5	8.7	5.7	2.9	0.0	-2.9	-5.7	-8.6	-11.5	-14.4	-17.3	-20.1	-23.0	-25.9	-28.8
130.	30.2	27.3	24.2	21.2	18.2	15.2	12.2	9.2	6.0	3.0	0.0	-3.0	-6.1	-9.1	-12.1	-15.1	-18.2	-21.2	-24.2	-27.2	-30.2
140.	31.8	28.7	25.4	22.3	19.1	16.0	12.8	9.6	6.3	3.2	0.0	-3.2	-6.3	-9.5	-12.7	-15.9	-19.0	-22.2	-25.3	-28.5	-31.6
150.	33.3	30.1	26.7	23.4	20.0	16.7	13.4	10.1	6.6	3.3	0.0	-3.3	-6.6	-9.9	-13.2	-16.6	-19.8	-23.1	-26.4	-29.7	-33.0
160.	34.8	31.4	27.8	24.4	20.8	17.5	13.9	10.5	6.9	3.5	0.0	-3.5	-6.9	-10.4	-13.8	-17.2	-20.6	-24.1	-27.5	-30.9	-34.3
170.	36.2	32.7	29.0	25.4	21.7	18.2	14.5	10.9	7.2	3.6	0.0	-3.6	-7.2	-10.7	-14.3	-17.9	-21.4	-24.9	-28.5	-32.0	-35.5
180.	37.6	33.9	30.0	26.3	22.5	18.8	15.0	11.3	7.4	3.7	0.0	-3.7	-7.4	-11.1	-14.8	-18.5	-22.1	-25.8	-29.4	-33.0	-36.6
190.	38.9	35.1	31.1	27.3	23.3	19.5	15.5	11.7	7.7	3.8	0.0	-3.8	-7.7	-11.5	-15.3	-19.0	-22.8	-26.6	-30.3	-34.0	-37.7
200.	40.2	36.3	32.1	28.1	24.0	20.1	16.0	12.0	7.9	4.0	0.0	-4.0	-7.9	-11.8	-15.7	-19.6	-23.5	-27.3	-31.2	-35.0	-38.8
210.	41.5	37.4	33.1	29.0	24.7	20.7	16.5	12.4	8.2	4.1	0.0	-4.1	-8.1	-12.1	-16.1	-20.1	-24.1	-28.0	-32.0	-35.9	-39.8
220.	42.7	38.4	34.0	29.8	25.4	21.2	16.9	12.7	8.4	4.2	0.0	-4.2	-8.3	-12.4	-16.5	-20.6	-24.7	-28.7	-32.7	-36.7	-40.7
230.	43.8	39.5	34.9	30.6	26.1	21.8	17.3	13.0	8.6	4.3	0.0	-4.3	-8.5	-12.7	-16.9	-21.1	-25.2	-29.4	-33.5	-37.6	-41.6
240.	44.9	40.4	35.8	31.3	26.7	22.3	17.8	13.3	8.8	4.4	0.0	-4.4	-8.7	-13.0	-17.3	-21.5	-25.8	-30.0	-34.2	-38.3	-42.4
250.	46.0	41.4	36.6	32.0	27.3	22.8	18.1	13.6	9.0	4.5	0.0	-4.5	-8.9	-13.3	-17.6	-22.0	-26.3	-30.5	-34.8	-39.0	-43.2
260.	47.0	42.3	37.4	32.7	27.9	23.3	18.5	13.9	9.1	4.6	0.0	-4.5	-9.0	-13.5	-17.9	-22.4	-26.7	-31.1	-35.4	-39.7	-43.9
270.	47.9	43.1	38.1	33.3	28.4	23.7	18.9	14.2	9.3	4.6	0.0	-4.6	-9.2	-13.8	-18.3	-22.7	-27.2	-31.6	-36.0	-40.3	-44.6
280.	48.9	43.9	38.8	34.0	28.9	24.1	19.2	14.4	9.5	4.7	0.0	-4.7	-9.3	-14.0	-18.5	-23.1	-27.6	-32.1	-36.5	-40.9	-45.3
290.	49.7	44.7	39.5	34.5	29.4	24.5	19.5	14.6	9.6	4.8	0.0	-4.8	-9.5	-14.2	-18.8	-23.4	-28.0	-32.5	-37.0	-41.4	-45.8
300.	50.5	45.4	40.1	35.1	29.8	24.9	19.8	14.9	9.8	4.9	0.0	-4.8	-9.6	-14.4	-19.0	-23.7	-28.3	-32.9	-37.4	-41.9	-46.4
310.	51.3	46.1	40.7	35.6	30.3	25.2	20.1	15.1	9.9	4.9	0.0	-4.9	-9.7	-14.5	-19.3	-24.0	-28.6	-33.2	-37.8	-42.4	-46.9
320.	52.0	46.8	41.3	36.1	30.7	25.6	20.3	15.2	10.0	5.0	0.0	-4.9	-9.8	-14.7	-19.5	-24.2	-28.9	-33.6	-38.2	-42.8	-47.3
330.	52.7	47.4	41.8	36.5	31.0	25.9	20.5	15.4	10.1	5.0	0.0	-5.0	-9.9	-14.8	-19.7	-24.5	-29.2	-33.9	-38.5	-43.1	-47.7
340.	53.4	47.9	42.3	36.9	31.4	26.2	20.8	15.6	10.2	5.1	0.0	-5.0	-10.0	-15.0	-19.8	-24.7	-29.4	-34.1	-38.8	-43.5	-48.0
350.	53.9	48.4	42.7	37.3	31.7	26.4	21.0	15.7	10.3	5.1	0.0	-5.1	-10.1	-15.1	-20.0	-24.8	-29.6	-34.4	-39.1	-43.7	-48.3
360.	54.5	48.9	43.1	37.6	32.0	26.6	21.1	15.8	10.4	5.2	0.0	-5.1	-10.2	-15.2	-20.1	-25.0	-29.8	-34.6	-39.3	-44.0	-48.6
370.	55.0	49.3	43.5	37.9	32.2	26.8	21.3	16.0	10.5	5.2	0.0	-5.2	-10.2	-15.3	-20.2	-25.1	-30.0	-34.8	-39.5	-44.2	-48.8
380.	55.4	49.7	43.8	38.2	32.5	27.0	21.4	16.1	10.5	5.2	0.0	-5.2	-10.3	-15.3	-20.3	-25.3	-30.1	-34.9	-39.7	-44.4	-49.0
390.	55.8	50.1	44.1	38.5	32.7	27.2	21.6	16.2	10.6	5.3	0.0	-5.2	-10.3	-15.4	-20.4	-25.4	-30.2	-35.0	-39.8	-44.5	-49.1
400.	56.2	50.4	44.4	38.7	32.8	27.3	21.7	16.2	10.6	5.3	0.0	-5.2	-10.4	-15.5	-20.5	-25.4	-30.3	-35.1	-39.9	-44.6	-49.2
410.	56.5	50.6	44.6	38.9	33.0	27.4	21.8	16.3	10.7	5.3	0.0	-5.2	-10.4	-15.5	-20.5	-25.5	-30.4	-35.2	-40.0	-44.7	-49.3
420.	56.8	50.9	44.8	39.0	33.1	27.5	21.8	16.3	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.5	-25.5	-30.4	-35.2	-40.0	-44.7	-49.3
430.	57.0	51.0	44.9	39.1	33.2	27.6	21.9	16.4	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.6	-25.5	-30.4	-35.2	-40.0	-44.7	-49.3
440.	57.1	51.2	45.0	39.2	33.3	27.7	21.9	16.4	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.6	-25.5	-30.4	-35.2	-40.0	-44.6	-49.2
450.	57.3	51.3	45.1	39.3	33.3	27.7	21.9	16.4	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.5	-25.5	-30.4	-35.2	-39.9	-44.6	-49.1
460.	57.4	51.3	45.2	39.3	33.3	27.7	21.9	16.4	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.5	-25.4	-30.3	-35.1	-39.8	-44.4	-49.0
470.	57.4	51.4	45.2	39.3	33.3	27.7	21.9	16.4	10.7	5.3	0.0	-5.3	-10.4	-15.5	-20.5	-25.4	-30.2	-35.0	-39.7	-44.3	-48.8
480.	57.4	51.4	45.1	39.3	33.3	27.6	21.9	16.4	10.7	5.3	0.0	-5.2	-10.4	-15.4	-20.4	-25.3	-30.1	-34.8	-39.5	-44.1	-48.6
490.	57.3	51.3	45.1	39.2	33.2	27.6	21.8	16.3	10.7	5.3	0.0	-5.2	-10.3	-15.4	-20.3	-25.2	-30.0	-34.7	-39.3	-43.9	-48.4
500.	57.2	51.2	45.0	39.1	33.1	27.5	21.8	16.3	10.6	5.3	0.0	-5.2	-10.3	-15.3	-20.2	-25.1	-29.8	-34.5	-39.1	-43.6	-48.1
510.	57.1	51.0	44.8	39.0	33.0	27.4	21.7	16.2	10.6	5.2	0.0	-5.2	-10.2	-15.2	-20.1	-24.9	-29.6	-34.3	-38.9	-43.4	-47.8
520.	56.9	50.9	44.7	38.8	32.9	27.3	21.6	16.1	10.5	5.2	0.0	-5.1	-10.2	-15.1	-20.0	-24.8	-29.5	-34.1	-38.6	-43.1	-47.4
530.	56.7	50.6	44.5	38.7	32.7	27.1	21.5	16.0	10.5	5.2	0.0	-5.1	-10.1	-15.0	-19.8	-24.6	-29.2	-33.8	-38.3	-42.7	-47.1
540.	56.4	50.4	44.2	38.4	32.5	27.0	21.3	15.9	10.4	5.2	0.0	-5.1	-10.0	-14.9	-19.7	-24.4	-29.0	-33.5	-38.0	-42.4	-46.6
550.	56.1	50.1	44.0	38.2	32.3	26.8	21.2	15.8	10.3	5.1	0.0	-5.0	-9.9	-14.8	-19.5	-24.2	-28.7	-33.2	-37.6	-42.0	-46.2
560.	55.7	49.7	43.6	37.9	32.0	26.6	21.0	15.7	10.2	5.1	0.0	-5.0	-9.9	-14.6	-19.3	-23.9	-28.5	-32.9	-37.3	-41.5	-45.7
570.	55.3	49.4	43.3	37.6	31.8	26.4	20.8	15.5	10.1	5.0	0.0	-4.9	-9.8	-14.5	-19.1	-23.7	-28.2	-32.5	-36.8	-41.1	-45.2
580.	54.8	48.9	42.9	37.3	31.5	26.1	20.6	15.4	10.0	5.0	0.0	-4.9	-9.7	-14.3	-18.9	-23.4	-27.8	-32.2	-36.4	-40.6	-44.7
590.	54.3	48.5	42.5	36.9	31.2	25.8	20.4	15.2	9.9	4.9	0.0	-4.8	-9.5	-14.2	-18.7	-23.1	-27.5	-31.8	-36.0	-40.1	-44.1
600.	53.8	48.0	42.1	36.5	30.8	25.6	20.2	15.0	9.8	4.9	0.0	-4.8	-9.4	-14.0	-18.5	-22.8	-27.1	-31.3	-35.5	-39.5	-43.5
610.	53.2	47.4	41.6	36.1	30.5	25.2	19.9	14.9	9.7	4.8	0.0	-4.7	-9.3	-13.8	-18.2	-22.5	-26.8	-30.9	-35.0	-38.9	-42.8
620.	52.5	46.9	41.1	35.6	30.1	24.9	19.7	14.7	9.6	4.7	0.0	-4.6	-9.2	-13.6	-17.9	-22.2	-26.4	-30.4	-34.4	-38.3	-42.2
630.	51.9	46.3	40.5	35.1	29.7	24.6	19.4	14.4	9.4	4.7	0.0	-4.6	-9.0	-13.4	-17.7	-21.8	-25.9	-29.9	-33.9	-37.7	-41.5
640.	51.1	45.6	39.9	34.6	29.2	24.2	19.1	14.2	9.3	4.6	0.0	-4.5	-8.9	-13.2	-17.4	-21.5	-25.5	-29.4	-33.3	-37.1	-40.8
650.	50.4	44.9	39.3	34.1	28.8	23.8	18.8	14.0	9.1	4.5	0.0	-4.4	-8.7	-12.9	-17.1	-21.1	-25.0	-28.9	-32.7	-36.4	-40.0
660.	49.6	44.2	38.7	33.5	28.3	23.4	18.5	13.7	9.0	4.4	0.0	-4.3	-8.6	-12.7	-16.7	-20.7	-24.6	-28.3	-32.1	-35.7	-39.2
670.	48.7	43.4	38.0	32.9	27.8	23.0	18.1	13.5	8.8	4.3	0.0	-4.3	-8.4	-12.5	-16.4	-20.3	-24.1	-27.8	-31.4	-34.9	-38.4
680.	47.8	42.6	37.3	32.3	27.2	22.5	17.8	13.2	8.6	4.3	0.0	-4.2	-8.2	-12.2	-16.1	-19.9	-23.5	-27.2	-30.7	-34.2	-37.6
690.	46.9	41.7	36.5	31.6	26.7	22.1	17.4	12.9	8.4	4.2	0.0	-4.1	-8.0	-11.9	-15.7	-19.4	-23.0	-26.5	-30.0	-33.4	-36.7
700.	45.9	40.9	35.7	30.9	26.1	21.6	17.0	12.6	8.2	4.1	0.0	-4.0	-7.9	-11.6	-15.3	-18.9	-22.5	-25.9	-29.3	-32.6	-35.8

11

Table 6 SR (2 g) correction for consistency

% C ↓ / Freeness →	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
100.	-47.4	-42.7	-38.0	-33.2	-28.5	-23.7	-19.0	-14.2	-9.5	-4.7	0.0	4.7	9.5	14.2	19.0	23.7	28.5	33.2	38.0	42.7	47.4
110.	-51.2	-46.1	-41.0	-35.8	-30.7	-25.6	-20.5	-15.4	-10.2	-5.1	0.0	5.1	10.2	15.4	20.5	25.6	30.7	35.8	41.0	46.1	51.2
120.	-54.8	-49.4	-43.9	-38.4	-32.9	-27.4	-21.9	-16.5	-11.0	-5.5	0.0	5.5	11.0	16.5	21.9	27.4	32.9	38.4	43.9	49.4	54.8
130.	-58.4	-52.5	-46.7	-40.9	-35.0	-29.2	-23.4	-17.5	-11.7	-5.8	0.0	5.8	11.7	17.5	23.4	29.2	35.0	40.9	46.7	52.5	58.4
140.	-61.8	-55.6	-49.5	-43.3	-37.1	-30.9	-24.7	-18.5	-12.4	-6.2	0.0	6.2	12.4	18.5	24.7	30.9	37.1	43.3	49.5	55.6	61.8
150.	-65.2	-58.6	-52.1	-45.6	-39.1	-32.6	-26.1	-19.5	-13.0	-6.5	0.0	6.5	13.0	19.5	26.1	32.6	39.1	45.6	52.1	58.6	65.2
160.	-68.4	-61.6	-54.7	-47.9	-41.0	-34.2	-27.4	-20.5	-13.7	-6.8	0.0	6.8	13.7	20.5	27.4	34.2	41.0	47.9	54.7	61.6	68.4
170.	-71.5	-64.4	-57.2	-50.1	-42.9	-35.8	-28.6	-21.5	-14.3	-7.2	0.0	7.2	14.3	21.5	28.6	35.8	42.9	50.1	57.2	64.4	71.5
180.	-74.6	-67.1	-59.7	-52.2	-44.7	-37.3	-29.8	-22.4	-14.9	-7.5	0.0	7.5	14.9	22.4	29.8	37.3	44.7	52.2	59.7	67.1	74.6
190.	-77.5	-69.8	-62.0	-54.3	-46.5	-38.8	-31.0	-23.3	-15.5	-7.8	0.0	7.8	15.5	23.3	31.0	38.8	46.5	54.3	62.0	69.8	77.5
200.	-80.4	-72.3	-64.3	-56.2	-48.2	-40.2	-32.1	-24.1	-16.1	-8.0	0.0	8.0	16.1	24.1	32.1	40.2	48.2	56.2	64.3	72.3	80.4
210.	-83.1	-74.8	-66.5	-58.2	-49.9	-41.6	-33.2	-24.9	-16.6	-8.3	0.0	8.3	16.6	24.9	33.2	41.5	49.9	58.2	66.5	74.8	83.1
220.	-85.7	-77.2	-68.6	-60.0	-51.4	-42.9	-34.3	-25.7	-17.2	-8.6	0.0	8.6	17.1	25.7	34.3	42.9	51.4	60.0	68.6	77.2	85.7
230.	-88.3	-79.5	-70.6	-61.8	-53.0	-44.2	-35.3	-26.5	-17.7	-8.8	0.0	8.8	17.7	26.5	35.3	44.1	53.0	61.8	70.6	79.5	88.3
240.	-90.8	-81.7	-72.6	-63.5	-54.5	-45.4	-36.3	-27.2	-18.2	-9.1	0.0	9.1	18.2	27.2	36.3	45.4	54.5	63.5	72.6	81.7	90.8
250.	-93.1	-83.8	-74.5	-65.2	-55.9	-46.6	-37.3	-27.9	-18.6	-9.3	0.0	9.3	18.6	27.9	37.2	46.6	55.9	65.2	74.5	83.8	93.1
260.	-95.4	-85.9	-76.3	-66.8	-57.2	-47.7	-38.2	-28.6	-19.1	-9.5	0.0	9.5	19.1	28.6	38.2	47.7	57.2	66.8	76.3	85.9	95.4
270.	-97.6	-87.8	-78.1	-68.3	-58.5	-48.8	-39.0	-29.3	-19.5	-9.8	0.0	9.8	19.5	29.3	39.0	48.8	58.5	68.3	78.1	87.8	97.6
280.	-99.7	-89.7	-79.7	-69.8	-59.8	-49.8	-39.9	-29.9	-19.9	-10.0	0.0	10.0	19.9	29.9	39.9	49.8	59.8	69.8	79.7	89.7	99.7
290.	-101.7	-91.5	-81.3	-71.2	-61.0	-50.8	-40.7	-30.5	-20.3	-10.2	0.0	10.2	20.3	30.5	40.7	50.8	61.0	71.2	81.3	91.5	101.7
300.	-103.6	-93.2	-82.9	-72.5	-62.1	-51.8	-41.4	-31.1	-20.7	-10.4	0.0	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.9	93.2	103.6
310.	-105.4	-94.9	-84.3	-73.8	-63.2	-52.7	-42.2	-31.6	-21.1	-10.5	0.0	10.5	21.1	31.6	42.2	52.7	63.2	73.8	84.3	94.8	105.4
320.	-107.1	-96.4	-85.7	-75.0	-64.3	-53.6	-42.8	-32.1	-21.4	-10.7	0.0	10.7	21.4	32.1	42.8	53.6	64.3	75.0	85.7	96.4	107.1
330.	-108.8	-97.9	-87.0	-76.1	-65.3	-54.4	-43.5	-32.6	-21.8	-10.9	0.0	10.9	21.8	32.6	43.5	54.4	65.3	76.1	87.0	97.9	108.8
340.	-110.3	-99.3	-88.3	-77.2	-66.2	-55.2	-44.1	-33.1	-22.1	-11.0	0.0	11.0	22.1	33.1	44.1	55.2	66.2	77.2	88.3	99.3	110.3
350.	-111.8	-100.6	-89.4	-78.3	-67.1	-55.9	-44.7	-33.5	-22.4	-11.2	0.0	11.2	22.4	33.5	44.7	55.9	67.1	78.2	89.4	100.6	111.8
360.	-113.2	-101.9	-90.5	-79.2	-67.9	-56.6	-45.3	-34.0	-22.6	-11.3	0.0	11.3	22.6	33.9	45.3	56.6	67.9	79.2	90.5	101.8	113.2
370.	-116.3	-104.6	-93.0	-81.4	-69.8	-58.1	-46.5	-34.9	-23.3	-11.6	0.0	11.6	23.2	34.9	46.5	58.1	69.7	81.4	93.0	104.6	116.3
380.	-117.2	-105.5	-93.8	-82.1	-70.3	-58.6	-46.9	-35.2	-23.4	-11.7	0.0	11.7	23.4	35.2	46.9	58.6	70.3	82.1	93.8	105.5	117.2
390.	-118.1	-106.3	-94.5	-82.7	-70.8	-59.0	-47.2	-35.4	-23.6	-11.8	0.0	11.8	23.6	35.4	47.2	59.0	70.8	82.7	94.5	106.3	118.1
400.	-118.8	-106.9	-95.0	-83.1	-71.3	-59.4	-47.5	-35.6	-23.8	-11.9	0.0	11.9	23.8	35.6	47.5	59.4	71.3	83.1	95.0	106.9	118.8
410.	-119.3	-107.4	-95.4	-83.5	-71.6	-59.6	-47.7	-35.8	-23.9	-11.9	0.0	11.9	23.9	35.8	47.7	59.6	71.6	83.5	95.4	107.4	119.3
420.	-119.7	-107.7	-95.7	-83.8	-71.8	-59.8	-47.9	-35.9	-23.9	-12.0	0.0	12.0	23.9	35.9	47.9	59.8	71.8	83.8	95.7	107.7	119.7
430.	-119.9	-107.9	-95.9	-83.9	-71.9	-59.9	-48.0	-36.0	-24.0	-12.0	0.0	12.0	24.0	36.0	48.0	59.9	71.9	83.9	95.9	107.9	119.9
440.	-120.0	-108.0	-96.0	-84.0	-72.0	-60.0	-48.0	-36.0	-24.0	-12.0	0.0	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0
450.	-119.9	-107.9	-95.9	-83.9	-71.9	-59.9	-48.0	-36.0	-24.0	-12.0	0.0	12.0	24.0	36.0	48.0	59.9	71.9	83.9	95.9	107.9	119.9
460.	-119.7	-107.7	-95.7	-83.8	-71.8	-59.8	-47.9	-35.9	-23.9	-12.0	0.0	12.0	23.9	35.9	47.9	59.8	71.8	83.8	95.7	107.7	119.7
470.	-119.3	-107.4	-95.5	-83.5	-71.6	-59.7	-47.7	-35.8	-23.9	-11.9	0.0	11.9	23.9	35.8	47.7	59.7	71.6	83.5	95.5	107.4	119.3
480.	-118.8	-106.9	-95.0	-83.2	-71.3	-59.4	-47.5	-35.6	-23.8	-11.9	0.0	11.9	23.8	35.6	47.5	59.4	71.3	83.2	95.0	106.9	118.8
490.	-118.2	-106.3	-94.5	-82.7	-70.9	-59.1	-47.3	-35.4	-23.6	-11.8	0.0	11.8	23.6	35.4	47.3	59.1	70.9	82.7	94.5	106.3	118.1
500.	-117.4	-105.6	-93.9	-82.1	-70.4	-58.7	-46.9	-35.2	-23.5	-11.7	0.0	11.7	23.5	35.2	46.9	58.7	70.4	82.1	93.9	105.6	117.4
510.	-116.0	-104.4	-92.8	-81.2	-69.6	-58.0	-46.4	-34.8	-23.2	-11.6	0.0	11.6	23.2	34.8	46.4	58.0	69.6	81.2	92.8	104.4	116.0
520.	-115.0	-103.5	-92.0	-80.5	-69.0	-57.5	-46.0	-34.5	-23.0	-11.5	0.0	11.5	23.0	34.5	46.0	57.5	69.0	80.5	92.0	103.5	115.0
530.	-114.0	-102.6	-91.2	-79.8	-68.4	-57.0	-45.6	-34.2	-22.8	-11.4	0.0	11.4	22.8	34.2	45.6	57.0	68.4	79.8	91.2	102.6	114.0
540.	-112.9	-101.6	-90.3	-79.0	-67.7	-56.5	-45.2	-33.9	-22.6	-11.3	0.0	11.3	22.6	33.9	45.2	56.5	67.7	79.0	90.3	101.6	112.9
550.	-111.8	-100.6	-89.4	-78.2	-67.1	-55.9	-44.7	-33.5	-22.4	-11.2	0.0	11.2	22.3	33.5	44.7	55.9	67.1	78.2	89.4	100.6	111.8
560.	-110.5	-99.5	-88.4	-77.4	-66.3	-55.3	-44.2	-33.2	-22.1	-11.1	0.0	11.1	22.1	33.2	44.2	55.3	66.3	77.4	88.4	99.5	110.5
570.	-109.3	-98.4	-87.4	-76.5	-65.6	-54.6	-43.7	-32.8	-21.9	-10.9	0.0	10.9	21.9	32.8	43.7	54.6	65.6	76.5	87.4	98.4	109.3
580.	-108.0	-97.2	-86.4	-75.6	-64.8	-54.0	-43.2	-32.4	-21.6	-10.8	0.0	10.8	21.6	32.4	43.2	54.0	64.8	75.6	86.4	97.2	108.0
590.	-106.6	-95.9	-85.3	-74.6	-64.0	-53.3	-42.6	-32.0	-21.3	-10.7	0.0	10.7	21.3	32.0	42.6	53.3	63.9	74.6	85.3	95.9	106.6
600.	-105.1	-94.6	-84.1	-73.6	-63.1	-52.6	-42.1	-31.5	-21.0	-10.5	0.0	10.5	21.0	31.5	42.1	52.6	63.1	73.6	84.1	94.6	105.1
610.	-103.7	-93.3	-82.9	-72.6	-62.2	-51.8	-41.5	-31.1	-20.7	-10.4	0.0	10.4	20.7	31.1	41.5	51.8	62.2	72.6	82.9	93.3	103.6
620.	-102.1	-91.9	-81.7	-71.5	-61.3	-51.1	-40.8	-30.6	-20.4	-10.2	0.0	10.2	20.4	30.6	40.8	51.0	61.3	71.5	81.7	91.9	102.1
630.	-100.5	-90.4	-80.4	-70.3	-60.3	-50.2	-40.2	-30.2	-20.1	-10.1	0.0	10.0	20.1	30.1	40.2	50.2	60.3	70.3	80.4	90.4	100.5
640.	-98.8	-88.9	-79.1	-69.2	-59.3	-49.4	-39.5	-29.7	-19.8	-9.9	0.0	9.9	19.8	29.6	39.5	49.4	59.3	69.2	79.1	88.9	98.8
650.	-97.1	-87.4	-77.7	-68.0	-58.3	-48.6	-38.8	-29.1	-19.4	-9.7	0.0	9.7	19.4	29.1	38.8	48.5	58.3	68.0	77.7	87.4	97.1
660.	-95.3	-85.8	-76.3	-66.7	-57.2	-47.7	-38.1	-28.6	-19.1	-9.5	0.0	9.5	19.1	28.6	38.1	47.6	57.2	66.7	76.2	85.8	95.3
670.	-93.5	-84.1	-74.8	-65.4	-56.1	-46.7	-37.4	-28.0	-18.7	-9.4	0.0	9.3	18.7	28.0	37.4	46.7	56.1	65.4	74.8	84.1	93.5
680.	-91.6	-82.4	-73.3	-64.1	-54.9	-45.8	-36.6	-27.5	-18.3	-9.2	0.0	9.2	18.3	27.5	36.6	45.8	54.9	64.1	73.2	82.4	91.6
690.	-89.6	-80.6	-71.7	-62.7	-53.8	-44.8	-35.8	-26.9	-17.9	-9.0	0.0	9.0	17.9	26.9	35.8	44.8	53.8	62.7	71.7	80.6	89.6
700.	-87.6	-78.8	-70.1	-61.3	-52.5	-43.8	-35.0	-26.3	-17.5	-8.8	0.0	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.6
710.	-85.5	-76.9	-68.4	-59.8	-51.3	-42.7	-34.2	-25.7	-17.1	-8.6	0.0	8.5	17.1	25.6	34.2	42.7	51.3	59.8	68.4	76.9	85.5
720.	-83.3	-75.0	-66.7	-58.3	-50.0	-41.7	-33.3	-25.0	-16.7	-8.3	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0	83.3
730.	-81.1	-73.0	-64.9	-56.8	-48.7	-40.6	-32.5	-24.3	-16.2	-8.1	0.0	8.1	16.2	24.3	32.4	40.6	48.7	56.8	64.9	73.0	81.1
740.	-78.9	-71.0	-63.1	-55.2	-47.3	-39.4	-31.6	-23.7	-15.8	-7.9	0.0	7.9	15.8	23.7	31.5	39.4	47.3	55.2	63.1	71.0	78.9
750.	-76.6	-68.9	-61.2	-53.6	-45.9	-38.3	-30.6	-23.0	-15.3	-7.7	0.0	7.6	15.3	23.0	30.6	38.3	45.9	53.6	61.2	68.9	76.5
760.	-74.2	-66.8	-59.3	-51.9	-44.5	-37.1	-29.7	-22.3	-14.8	-7.4	0.0	7.4	14.8	22.2	29.7	37.1	44.5	51.9	59.3	66.7	74.2
770.	-71.7	-64.6	-57.4	-50.2	-43.0	-35.9	-28.7	-21.5	-14.3	-7.2	0.0	7.2	14.3	21.5	28.7	35.9	43.0	50.2	57.4	64.5	71.7
780.	-69.2	-62.3	-55.4	-48.5	-41.5	-34.6	-27.7	-20.8	-13.8	-6.9	0.0	6.9	13.8	20.8	27.7	34.6	41.5	48.4	55.4	62.3	69.2
790.	-66.6	-60.0	-53.3	-46.7	-40.0	-33.3	-26.7	-20.0	-13.3	-6.7	0.0	6.7	13.3	20.0	26.7	33.3	40.0	46.6	53.3	60.0	66.6
800.	-64.0	-57.6	-51.2	-44.8	-38.4	-32.0	-25.6	-19.2	-12.8	-6.4	0.0	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0
810.	-61.3	-55.2	-49.1	-42.9	-36.8	-30.7	-24.5	-18.4	-12.3	-6.1	0.0	6.1	12.3	18.4	24.5	30.7	36.8	42.9	49.0	55.2	61.3
820.	-58.6	-52.7	-46.9	-41.0	-35.1	-29.3	-23.4	-17.6	-11.7	-5.9	0.0	5.9	11.7	17.6	23.4	29.3	35.1	41.0	46.8	52.7	58.6
830.	-55.7	-50.2	-44.6	-39.0	-33.4	-27.9	-22.3	-16.7	-11.1	-5.6	0.0	5.6	11.1	16.7	22.3	27.9	33.4	39.0	44.6	50.2	55.7
840.	-52.9	-47.6	-42.3	-37.0	-31.7	-26.4	-21.1	-15.9	-10.6	-5.3	0.0	5.3	10.6	15.9	21.1	26.4	31.7	37.0	42.3	47.6	52.9
850.	-49.9	-44.9	-39.9	-34.9	-30.0	-25.0	-20.0	-15.0	-10.0	-5.0	0.0	5.0	10.0	15.0	20.0	25.0	30.0	34.9	39.9	44.9	49.9
860.	-46.9	-42.2	-37.5	-32.8	-28.1	-23.5	-18.8	-14.1	-9.4	-4.7	0.0	4.7	9.4	14.1	18.8	23.5	28.1	32.8	37.5	42.2	46.9
870.	-43.8	-39.5	-35.1	-30.7	-26.3	-21.9	-17.5	-13.2	-8.8	-4.4	0.0	4.4	8.8	13.2	17.5	21.9	26.3	30.7	35.1	39.5	43.8
880.	-40.7	-36.6	-32.6	-28.5	-24.4	-20.3	-16.3	-12.2	-8.1	-4.1	0.0	4.1	8.1	12.2	16.3	20.3	24.4	28.5	32.5	36.6	40.7
890.	-37.5	-33.7	-30.0	-26.2	-22.5	-18.7	-15.0	-11.2	-7.5	-3.8	0.0	3.7	7.5	11.2	15.0	18.7	22.5	26.2	30.0	33.7	37.5
900.	-34.2	-30.8	-27.4	-23.9	-20.5	-17.1	-13.7	-10.3	-6.8	-3.4	0.0	3.4	6.8	10.3	13.7	17.1	20.5	23.9	27.4	30.8	34.2

12

Table 7 SR (2 g) correction for temperature

Temp. ↓ / Freeness →	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
100.	28.9	25.5	22.1	18.9	15.8	13.0	10.1	7.5	4.8	2.4	0.0	-2.3	-4.5	-6.6	-8.6	-10.6	-12.5	-14.3	-16.0	-17.7	-19.4
110.	31.2	27.5	23.8	20.4	17.1	14.0	10.9	8.1	5.2	2.6	0.0	-2.5	-4.8	-7.1	-9.3	-11.4	-13.4	-15.4	-17.3	-19.1	-20.9
120.	33.4	29.4	25.5	21.9	18.3	15.0	11.7	8.6	5.6	2.7	0.0	-2.6	-5.2	-7.6	-10.0	-12.2	-14.4	-16.5	-18.5	-20.5	-22.4
130.	35.5	31.3	27.2	23.3	19.5	16.0	12.5	9.2	5.9	2.9	0.0	-2.8	-5.5	-8.1	-10.6	-13.0	-15.3	-17.6	-19.7	-21.8	-23.8
140.	37.6	33.2	28.8	24.7	20.6	16.9	13.2	9.7	6.3	3.1	0.0	-3.0	-5.8	-8.6	-11.2	-13.8	-16.2	-18.6	-20.9	-23.1	-25.2
150.	39.7	35.0	30.3	26.0	21.7	17.8	13.9	10.3	6.6	3.3	0.0	-3.1	-6.1	-9.0	-11.8	-14.5	-17.1	-19.6	-22.0	-24.3	-26.6
160.	41.6	36.7	31.8	27.3	22.8	18.7	14.6	10.8	7.0	3.4	0.0	-3.3	-6.4	-9.5	-12.4	-15.2	-18.0	-20.6	-23.1	-25.6	-27.9
170.	43.6	38.4	33.3	28.6	23.8	19.6	15.3	11.3	7.3	3.6	0.0	-3.4	-6.7	-9.9	-13.0	-15.9	-18.8	-21.5	-24.2	-26.7	-29.2
180.	45.4	40.0	34.7	29.8	24.9	20.4	15.9	11.8	7.6	3.7	0.0	-3.6	-7.0	-10.3	-13.5	-16.6	-19.6	-22.4	-25.2	-27.9	-30.4
190.	47.2	41.6	36.0	30.9	25.8	21.2	16.6	12.2	7.9	3.9	0.0	-3.7	-7.3	-10.8	-14.1	-17.3	-20.3	-23.3	-26.2	-29.0	-31.6
200.	48.9	43.1	37.4	32.1	26.8	22.0	17.2	12.7	8.2	4.0	0.0	-3.9	-7.6	-11.1	-14.6	-17.9	-21.1	-24.2	-27.2	-30.0	-32.8
210.	50.6	44.6	38.6	33.2	27.7	22.7	17.7	13.1	8.5	4.1	0.0	-4.0	-7.8	-11.5	-15.1	-18.5	-21.8	-25.0	-28.1	-31.1	-33.9
220.	52.2	46.0	39.9	34.2	28.6	23.4	18.3	13.5	8.7	4.3	0.0	-4.1	-8.1	-11.9	-15.6	-19.1	-22.5	-25.8	-29.0	-32.0	-35.0
230.	53.8	47.4	41.1	35.2	29.4	24.1	18.9	13.9	9.0	4.4	0.0	-4.2	-8.3	-12.2	-16.0	-19.7	-23.2	-26.6	-29.8	-33.0	-36.0
240.	55.3	48.7	42.2	36.2	30.3	24.8	19.4	14.3	9.2	4.5	0.0	-4.4	-8.6	-12.6	-16.5	-20.2	-23.8	-27.3	-30.7	-33.9	-37.0
250.	56.7	50.0	43.3	37.2	31.0	25.5	19.9	14.7	9.5	4.6	0.0	-4.5	-8.8	-12.9	-16.9	-20.7	-24.4	-28.0	-31.5	-34.8	-38.0
260.	58.1	51.2	44.4	38.1	31.8	26.1	20.4	15.0	9.7	4.8	0.0	-4.6	-9.0	-13.2	-17.3	-21.3	-25.0	-28.7	-32.2	-35.6	-38.9
270.	59.4	52.4	45.4	39.0	32.5	26.7	20.8	15.4	9.9	4.9	0.0	-4.7	-9.2	-13.5	-17.7	-21.7	-25.6	-29.4	-33.0	-36.5	-39.8
280.	60.7	53.5	46.3	39.8	33.2	27.3	21.3	15.7	10.1	5.0	0.0	-4.8	-9.4	-13.8	-18.1	-22.2	-26.2	-30.0	-33.7	-37.2	-40.7
290.	61.9	54.6	47.3	40.6	33.9	27.8	21.7	16.0	10.3	5.1	0.0	-4.9	-9.6	-14.1	-18.4	-22.6	-26.7	-30.6	-34.4	-38.0	-41.5
300.	63.0	55.6	48.2	41.3	34.5	28.3	22.1	16.3	10.5	5.2	0.0	-5.0	-9.8	-14.4	-18.8	-23.1	-27.2	-31.2	-35.0	-38.7	-42.3
310.	64.2	56.6	49.0	42.1	35.1	28.8	22.5	16.6	10.7	5.3	0.0	-5.1	-9.9	-14.6	-19.1	-23.5	-27.7	-31.7	-35.6	-39.4	-43.0
320.	65.2	57.5	49.8	42.8	35.7	29.3	22.9	16.9	10.9	5.3	0.0	-5.2	-10.1	-14.9	-19.4	-23.9	-28.1	-32.2	-36.2	-40.0	-43.7
330.	66.2	58.4	50.6	43.4	36.3	29.7	23.2	17.1	11.1	5.4	0.0	-5.2	-10.2	-15.1	-19.7	-24.2	-28.5	-32.7	-36.8	-40.6	-44.4
340.	67.2	59.2	51.3	44.0	36.8	30.2	23.6	17.4	11.2	5.5	0.0	-5.3	-10.4	-15.3	-20.0	-24.6	-29.0	-33.2	-37.3	-41.2	-45.0
350.	68.1	60.0	52.0	44.6	37.3	30.6	23.9	17.6	11.4	5.6	0.0	-5.4	-10.5	-15.5	-20.3	-24.9	-29.3	-33.6	-37.8	-41.8	-45.6
360.	68.9	60.8	52.6	45.2	37.7	30.9	24.2	17.8	11.5	5.6	0.0	-5.4	-10.7	-15.7	-20.5	-25.2	-29.7	-34.0	-38.2	-42.3	-46.2
370.	70.8	62.4	54.1	46.4	38.7	31.8	24.8	18.3	11.8	5.8	0.0	-5.6	-11.0	-16.1	-21.1	-25.9	-30.5	-35.0	-39.3	-43.4	-47.5
380.	71.4	62.9	54.5	46.8	39.1	32.1	25.0	18.5	11.9	5.8	0.0	-5.6	-11.0	-16.3	-21.3	-26.1	-30.8	-35.3	-39.6	-43.8	-47.9
390.	71.9	63.4	54.9	47.1	39.4	32.3	25.2	18.6	12.0	5.9	0.0	-5.7	-11.1	-16.4	-21.4	-26.3	-31.0	-35.5	-39.9	-44.1	-48.2
400.	72.3	63.8	55.2	47.4	39.6	32.5	25.4	18.7	12.1	5.9	0.0	-5.7	-11.2	-16.5	-21.5	-26.5	-31.2	-35.7	-40.1	-44.4	-48.5
410.	72.6	64.1	55.5	47.6	39.8	32.6	25.5	18.8	12.1	6.0	0.0	-5.7	-11.2	-16.5	-21.6	-26.6	-31.3	-35.9	-40.3	-44.6	-48.7
420.	72.9	64.3	55.7	47.8	39.9	32.7	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.7	-26.7	-31.4	-36.0	-40.4	-44.7	-48.8
430.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-48.9
440.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-49.0
450.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-48.9
460.	72.9	64.3	55.7	47.8	39.9	32.7	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.7	-26.7	-31.4	-36.0	-40.4	-44.7	-48.9
470.	72.6	64.1	55.5	47.6	39.8	32.6	25.5	18.8	12.1	6.0	0.0	-5.7	-11.2	-16.6	-21.6	-26.6	-31.3	-35.9	-40.3	-44.6	-48.7
480.	72.3	63.8	55.3	47.4	39.6	32.5	25.4	18.7	12.1	5.9	0.0	-5.7	-11.2	-16.5	-21.6	-26.5	-31.2	-35.7	-40.1	-44.4	-48.5
490.	71.9	63.4	54.9	47.2	39.4	32.3	25.2	18.6	12.0	5.9	0.0	-5.7	-11.1	-16.4	-21.4	-26.3	-31.0	-35.5	-39.9	-44.1	-48.2
500.	71.4	63.0	54.6	46.8	39.1	32.1	25.1	18.5	11.9	5.9	0.0	-5.6	-11.1	-16.3	-21.3	-26.1	-30.8	-35.3	-39.7	-43.9	-47.9
510.	70.6	62.3	54.0	46.3	38.7	31.7	24.8	18.3	11.8	5.8	0.0	-5.6	-10.9	-16.1	-21.1	-25.8	-30.5	-34.9	-39.2	-43.4	-47.4
520.	70.0	61.8	53.5	45.9	38.3	31.5	24.6	18.1	11.7	5.7	0.0	-5.5	-10.8	-16.0	-20.9	-25.6	-30.2	-34.6	-38.9	-43.0	-47.0
530.	69.4	61.2	53.0	45.5	38.0	31.2	24.3	18.0	11.6	5.7	0.0	-5.5	-10.7	-15.8	-20.7	-25.4	-29.9	-34.3	-38.5	-42.6	-46.5
540.	68.7	60.6	52.5	45.1	37.6	30.9	24.1	17.8	11.5	5.6	0.0	-5.4	-10.6	-15.7	-20.5	-25.2	-29.6	-34.0	-38.2	-42.2	-46.1
550.	68.0	60.0	52.0	44.6	37.3	30.6	23.9	17.6	11.4	5.6	0.0	-5.4	-10.5	-15.5	-20.3	-24.9	-29.3	-33.6	-37.8	-41.8	-45.6
560.	67.3	59.4	51.4	44.1	36.8	30.2	23.6	17.4	11.3	5.5	0.0	-5.3	-10.4	-15.3	-20.1	-24.6	-29.0	-33.3	-37.4	-41.3	-45.1
570.	66.5	58.7	50.8	43.6	36.4	29.9	23.3	17.2	11.1	5.5	0.0	-5.3	-10.3	-15.2	-19.8	-24.3	-28.7	-32.9	-36.9	-40.8	-44.6
580.	65.7	58.0	50.2	43.1	36.0	29.5	23.1	17.0	11.0	5.4	0.0	-5.2	-10.2	-15.0	-19.6	-24.1	-28.3	-32.5	-36.5	-40.3	-44.1
590.	64.9	57.2	49.6	42.5	35.5	29.1	22.8	16.8	10.8	5.3	0.0	-5.1	-10.0	-14.8	-19.3	-23.7	-28.0	-32.1	-36.0	-39.8	-43.5
600.	64.0	56.5	48.9	42.0	35.0	28.7	22.5	16.6	10.7	5.2	0.0	-5.1	-9.9	-14.6	-19.1	-23.4	-27.6	-31.6	-35.5	-39.3	-42.9
610.	63.1	55.6	48.2	41.4	34.5	28.3	22.1	16.3	10.5	5.2	0.0	-5.0	-9.8	-14.4	-18.8	-23.1	-27.2	-31.2	-35.0	-38.7	-42.3
620.	62.2	54.8	47.5	40.8	34.0	27.9	21.8	16.1	10.4	5.1	0.0	-4.9	-9.6	-14.2	-18.5	-22.7	-26.8	-30.7	-34.5	-38.2	-41.7
630.	61.2	54.0	46.7	40.1	33.5	27.5	21.5	15.8	10.2	5.0	0.0	-4.8	-9.5	-13.9	-18.2	-22.4	-26.4	-30.2	-34.0	-37.6	-41.0
640.	60.2	53.1	46.0	39.4	32.9	27.0	21.1	15.6	10.1	4.9	0.0	-4.8	-9.3	-13.7	-17.9	-22.0	-25.9	-29.7	-33.4	-36.9	-40.3
650.	59.1	52.1	45.2	38.8	32.4	26.5	20.7	15.3	9.9	4.8	0.0	-4.7	-9.2	-13.5	-17.6	-21.6	-25.5	-29.2	-32.8	-36.3	-39.6
660.	58.0	51.2	44.3	38.0	31.8	26.1	20.4	15.0	9.7	4.8	0.0	-4.6	-9.0	-13.2	-17.3	-21.2	-25.0	-28.7	-32.2	-35.6	-38.9
670.	56.9	50.2	43.5	37.3	31.1	25.6	20.0	14.7	9.5	4.7	0.0	-4.5	-8.8	-13.0	-17.0	-20.8	-24.5	-28.1	-31.6	-34.9	-38.2
680.	55.7	49.2	42.6	36.5	30.5	25.0	19.5	14.4	9.3	4.6	0.0	-4.4	-8.6	-12.7	-16.6	-20.4	-24.0	-27.5	-30.9	-34.2	-37.4
690.	54.5	48.1	41.7	35.8	29.9	24.5	19.1	14.1	9.1	4.5	0.0	-4.3	-8.4	-12.4	-16.3	-20.0	-23.5	-27.0	-30.3	-33.5	-36.6
700.	53.3	47.0	40.7	35.0	29.2	23.9	18.7	13.8	8.9	4.4	0.0	-4.2	-8.3	-12.2	-15.9	-19.5	-23.0	-26.3	-29.6	-32.7	-35.7
710.	52.0	45.9	39.8	34.1	28.5	23.4	18.3	13.5	8.7	4.3	0.0	-4.1	-8.1	-11.9	-15.5	-19.0	-22.4	-25.7	-28.9	-31.9	-34.9
720.	50.7	44.7	38.8	33.3	27.8	22.8	17.8	13.1	8.5	4.2	0.0	-4.0	-7.9	-11.6	-15.1	-18.6	-21.9	-25.1	-28.2	-31.1	-34.0
730.	49.4	43.6	37.7	32.4	27.0	22.2	17.3	12.8	8.3	4.0	0.0	-3.9	-7.7	-11.3	-14.7	-18.1	-21.3	-24.4	-27.4	-30.3	-33.1
740.	48.0	42.3	36.7	31.5	26.3	21.6	16.8	12.4	8.0	3.9	0.0	-3.8	-7.4	-10.9	-14.3	-17.6	-20.7	-23.7	-26.7	-29.5	-32.2
750.	46.6	41.1	35.6	30.6	25.5	20.9	16.3	12.1	7.8	3.8	0.0	-3.7	-7.2	-10.6	-13.9	-17.1	-20.1	-23.0	-25.9	-28.6	-31.3
760.	45.1	39.8	34.5	29.6	24.7	20.3	15.8	11.7	7.5	3.7	0.0	-3.6	-7.0	-10.3	-13.5	-16.5	-19.5	-22.3	-25.1	-27.7	-30.3
770.	43.7	38.5	33.3	28.6	23.9	19.6	15.3	11.3	7.3	3.6	0.0	-3.5	-6.8	-10.0	-13.0	-16.0	-18.8	-21.6	-24.2	-26.8	-29.3
780.	42.1	37.2	32.2	27.6	23.1	18.9	14.8	10.9	7.0	3.4	0.0	-3.3	-6.5	-9.6	-12.6	-15.4	-18.2	-20.8	-23.4	-25.9	-28.3
790.	40.6	35.8	31.0	26.6	22.2	18.2	14.2	10.5	6.8	3.3	0.0	-3.2	-6.3	-9.3	-12.1	-14.9	-17.5	-20.1	-22.5	-24.9	-27.2
800.	39.0	34.4	29.8	25.5	21.3	17.5	13.7	10.1	6.5	3.2	0.0	-3.1	-6.0	-8.9	-11.6	-14.3	-16.8	-19.3	-21.6	-23.9	-26.1
810.	37.3	32.9	28.5	24.5	20.4	16.8	13.1	9.7	6.2	3.1	0.0	-3.0	-5.8	-8.5	-11.1	-13.7	-16.1	-18.5	-20.7	-22.9	-25.0
820.	35.6	31.4	27.2	23.4	19.5	16.0	12.5	9.2	6.0	2.9	0.0	-2.8	-5.5	-8.1	-10.6	-13.1	-15.4	-17.6	-19.8	-21.9	-23.9
830.	33.9	29.9	25.9	22.3	18.6	15.2	11.9	8.8	5.7	2.8	0.0	-2.7	-5.3	-7.7	-10.1	-12.4	-14.6	-16.8	-18.8	-20.8	-22.8
840.	32.2	28.4	24.6	21.1	17.6	14.5	11.3	8.3	5.4	2.6	0.0	-2.5	-5.0	-7.3	-9.6	-11.8	-13.9	-15.9	-17.9	-19.8	-21.6
850.	30.4	26.8	23.2	19.9	16.6	13.7	10.7	7.9	5.1	2.5	0.0	-2.4	-4.7	-6.9	-9.1	-11.1	-13.1	-15.0	-16.9	-18.7	-20.4
860.	28.6	25.2	21.8	18.7	15.6	12.8	10.0	7.4	4.8	2.3	0.0	-2.3	-4.4	-6.5	-8.5	-10.4	-12.3	-14.1	-15.9	-17.5	-19.1
870.	26.7	23.5	20.4	17.5	14.6	12.0	9.4	6.9	4.5	2.2	0.0	-2.1	-4.1	-6.1	-8.0	-9.8	-11.5	-13.2	-14.8	-16.4	-17.9
880.	24.8	21.8	18.9	16.2	13.6	11.1	8.7	6.4	4.1	2.0	0.0	-2.0	-3.8	-5.6	-7.4	-9.1	-10.7	-12.2	-13.8	-15.2	-16.6
890.	22.8	20.1	17.4	15.0	12.5	10.2	8.0	5.9	3.8	1.9	0.0	-1.8	-3.5	-5.2	-6.8	-8.4	-9.8	-11.3	-12.7	-14.0	-15.3
900.	20.8	18.4	15.9	13.6	11.4	9.3	7.3	5.4	3.5	1.7	0.0	-1.6	-3.2	-4.7	-6.2	-7.6	-9.0	-10.3	-11.6	-12.8	-14.0

13

Table 8 SR (9.5 g) correction for consistency

% C / Freeness	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05
100.	-10.0	-9.0	-8.0	-7.0	-6.0	-5.0	-4.0	-3.0	-2.0	-1.0	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
110.	-10.8	-9.7	-8.6	-7.5	-6.5	-5.4	-4.3	-3.2	-2.2	-1.1	0.0	1.1	2.2	3.2	4.3	5.4	6.5	7.5	8.6	9.7	10.8
120.	-11.5	-10.4	-9.2	-8.1	-6.9	-5.8	-4.6	-3.5	-2.3	-1.2	0.0	1.2	2.3	3.5	4.6	5.8	6.9	8.1	9.2	10.4	11.5
130.	-12.3	-11.1	-9.8	-8.6	-7.4	-6.1	-4.9	-3.7	-2.5	-1.2	0.0	1.2	2.5	3.7	4.9	6.1	7.4	8.6	9.8	11.1	12.3
140.	-13.0	-11.7	-10.4	-9.1	-7.8	-6.5	-5.2	-3.9	-2.6	-1.3	0.0	1.3	2.6	3.9	5.2	6.5	7.8	9.1	10.4	11.7	13.0
150.	-13.7	-12.3	-11.0	-9.6	-8.2	-6.9	-5.5	-4.1	-2.7	-1.4	0.0	1.4	2.7	4.1	5.5	6.9	8.2	9.6	11.0	12.3	13.7
160.	-14.4	-13.0	-11.5	-10.1	-8.6	-7.2	-5.8	-4.3	-2.9	-1.4	0.0	1.4	2.9	4.3	5.8	7.2	8.6	10.1	11.5	13.0	14.4
170.	-15.1	-13.6	-12.0	-10.5	-9.0	-7.5	-6.0	-4.5	-3.0	-1.5	0.0	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.6	15.1
180.	-15.7	-14.1	-12.6	-11.0	-9.4	-7.9	-6.3	-4.7	-3.1	-1.6	0.0	1.6	3.1	4.7	6.3	7.8	9.4	11.0	12.6	14.1	15.7
190.	-16.3	-14.7	-13.1	-11.4	-9.8	-8.2	-6.5	-4.9	-3.3	-1.6	0.0	1.6	3.3	4.9	6.5	8.2	9.8	11.4	13.1	14.7	16.3
200.	-16.9	-15.2	-13.5	-11.8	-10.2	-8.5	-6.8	-5.1	-3.4	-1.7	0.0	1.7	3.4	5.1	6.8	8.5	10.1	11.8	13.5	15.2	16.9
210.	-17.5	-15.7	-14.0	-12.2	-10.5	-8.7	-7.0	-5.2	-3.5	-1.7	0.0	1.7	3.5	5.2	7.0	8.7	10.5	12.2	14.0	15.7	17.5
220.	-18.1	-16.2	-14.4	-12.6	-10.8	-9.0	-7.2	-5.4	-3.6	-1.8	0.0	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18.1
230.	-18.6	-16.7	-14.9	-13.0	-11.2	-9.3	-7.4	-5.6	-3.7	-1.9	0.0	1.9	3.7	5.6	7.4	9.3	11.2	13.0	14.9	16.7	18.6
240.	-19.1	-17.2	-15.3	-13.4	-11.5	-9.6	-7.6	-5.7	-3.8	-1.9	0.0	1.9	3.8	5.7	7.6	9.6	11.5	13.4	15.3	17.2	19.1
250.	-19.6	-17.6	-15.7	-13.7	-11.8	-9.8	-7.8	-5.9	-3.9	-2.0	0.0	2.0	3.9	5.9	7.8	9.8	11.8	13.7	15.7	17.6	19.6
260.	-20.1	-18.1	-16.1	-14.1	-12.1	-10.0	-8.0	-6.0	-4.0	-2.0	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.1	16.1	18.1	20.1
270.	-20.5	-18.5	-16.4	-14.4	-12.3	-10.3	-8.2	-6.2	-4.1	-2.1	0.0	2.1	4.1	6.2	8.2	10.3	12.3	14.4	16.4	18.5	20.5
280.	-21.0	-18.9	-16.8	-14.7	-12.6	-10.5	-8.4	-6.3	-4.2	-2.1	0.0	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0
290.	-21.4	-19.3	-17.1	-15.0	-12.8	-10.7	-8.6	-6.4	-4.3	-2.1	0.0	2.1	4.3	6.4	8.6	10.7	12.8	15.0	17.1	19.3	21.4
300.	-21.8	-19.6	-17.4	-15.3	-13.1	-10.9	-8.7	-6.5	-4.4	-2.2	0.0	2.2	4.4	6.5	8.7	10.9	13.1	15.3	17.4	19.6	21.8
310.	-22.2	-20.0	-17.8	-15.5	-13.3	-11.1	-8.9	-6.7	-4.4	-2.2	0.0	2.2	4.4	6.7	8.9	11.1	13.3	15.5	17.7	20.0	22.2
320.	-22.6	-20.3	-18.0	-15.8	-13.5	-11.3	-9.0	-6.8	-4.5	-2.3	0.0	2.3	4.5	6.8	9.0	11.3	13.5	15.8	18.0	20.3	22.5
330.	-22.9	-20.6	-18.3	-16.0	-13.7	-11.5	-9.2	-6.9	-4.6	-2.3	0.0	2.3	4.6	6.9	9.2	11.4	13.7	16.0	18.3	20.6	22.9
340.	-23.2	-20.9	-18.6	-16.3	-13.9	-11.6	-9.3	-7.0	-4.6	-2.3	0.0	2.3	4.6	7.0	9.3	11.6	13.9	16.3	18.6	20.9	23.2
350.	-23.5	-21.2	-18.8	-16.5	-14.1	-11.8	-9.4	-7.1	-4.7	-2.4	0.0	2.4	4.7	7.1	9.4	11.8	14.1	16.5	18.8	21.2	23.5
360.	-23.8	-21.4	-19.1	-16.7	-14.3	-11.9	-9.5	-7.2	-4.8	-2.4	0.0	2.4	4.8	7.1	9.5	11.9	14.3	16.7	19.1	21.4	23.8
370.	-24.5	-22.0	-19.6	-17.1	-14.7	-12.2	-9.8	-7.3	-4.9	-2.4	0.0	2.4	4.9	7.3	9.8	12.2	14.7	17.1	19.6	22.0	24.5
380.	-24.7	-22.2	-19.7	-17.3	-14.8	-12.3	-9.9	-7.4	-4.9	-2.5	0.0	2.5	4.9	7.4	9.9	12.3	14.8	17.3	19.7	22.2	24.7
390.	-24.9	-22.4	-19.9	-17.4	-14.9	-12.4	-9.9	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	9.9	12.4	14.9	17.4	19.9	22.4	24.9
400.	-25.0	-22.5	-20.0	-17.5	-15.0	-12.5	-10.0	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
410.	-25.1	-22.6	-20.1	-17.6	-15.1	-12.6	-10.0	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	10.0	12.6	15.1	17.6	20.1	22.6	25.1
420.	-25.2	-22.7	-20.2	-17.6	-15.1	-12.6	-10.1	-7.6	-5.0	-2.5	0.0	2.5	5.0	7.6	10.1	12.6	15.1	17.6	20.2	22.7	25.2
430.	-25.2	-22.7	-20.2	-17.7	-15.1	-12.6	-10.1	-7.6	-5.0	-2.5	0.0	2.5	5.0	7.6	10.1	12.6	15.1	17.7	20.2	22.7	25.2
440.	-25.3	-22.7	-20.2	-17.7	-15.2	-12.6	-10.1	-7.6	-5.1	-2.5	0.0	2.5	5.1	7.6	10.1	12.6	15.2	17.7	20.2	22.7	25.3
450.	-25.2	-22.7	-20.2	-17.7	-15.1	-12.6	-10.1	-7.6	-5.0	-2.5	0.0	2.5	5.0	7.6	10.1	12.6	15.1	17.7	20.2	22.7	25.2
460.	-25.2	-22.7	-20.2	-17.6	-15.1	-12.6	-10.1	-7.6	-5.0	-2.5	0.0	2.5	5.0	7.6	10.1	12.6	15.1	17.6	20.2	22.7	25.2
470.	-25.1	-22.6	-20.1	-17.6	-15.1	-12.6	-10.0	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	10.0	12.6	15.1	17.6	20.1	22.6	25.1
480.	-25.0	-22.5	-20.0	-17.5	-15.0	-12.5	-10.0	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
490.	-24.9	-22.4	-19.9	-17.4	-14.9	-12.4	-9.9	-7.5	-5.0	-2.5	0.0	2.5	5.0	7.5	9.9	12.4	14.9	17.4	19.9	22.4	24.9
500.	-24.7	-22.2	-19.8	-17.3	-14.8	-12.4	-9.9	-7.4	-4.9	-2.5	0.0	2.5	4.9	7.4	9.9	12.4	14.8	17.3	19.8	22.2	24.7
510.	-24.4	-22.0	-19.5	-17.1	-14.7	-12.2	-9.8	-7.3	-4.9	-2.4	0.0	2.4	4.9	7.3	9.8	12.2	14.7	17.1	19.5	22.0	24.4
520.	-24.2	-21.8	-19.4	-17.0	-14.5	-12.1	-9.7	-7.3	-4.8	-2.4	0.0	2.4	4.8	7.3	9.7	12.1	14.5	17.0	19.4	21.8	24.2
530.	-24.0	-21.6	-19.2	-16.8	-14.4	-12.0	-9.6	-7.2	-4.8	-2.4	0.0	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0
540.	-23.8	-21.4	-19.0	-16.6	-14.3	-11.9	-9.5	-7.1	-4.8	-2.4	0.0	2.4	4.8	7.1	9.5	11.9	14.3	16.6	19.0	21.4	23.8
550.	-23.5	-21.2	-18.8	-16.5	-14.1	-11.8	-9.4	-7.1	-4.7	-2.4	0.0	2.4	4.7	7.1	9.4	11.8	14.1	16.5	18.8	21.2	23.5
560.	-23.3	-20.9	-18.6	-16.3	-14.0	-11.6	-9.3	-7.0	-4.7	-2.3	0.0	2.3	4.7	7.0	9.3	11.6	14.0	16.3	18.6	20.9	23.3
570.	-23.0	-20.7	-18.4	-16.1	-13.8	-11.5	-9.2	-6.9	-4.6	-2.3	0.0	2.3	4.6	6.9	9.2	11.5	13.8	16.1	18.4	20.7	23.0
580.	-22.7	-20.5	-18.2	-15.9	-13.6	-11.4	-9.1	-6.8	-4.5	-2.3	0.0	2.3	4.5	6.8	9.1	11.4	13.6	15.9	18.2	20.5	22.7
590.	-22.4	-20.2	-18.0	-15.7	-13.5	-11.2	-9.0	-6.7	-4.5	-2.2	0.0	2.2	4.5	6.7	9.0	11.2	13.5	15.7	17.9	20.2	22.4
600.	-22.1	-19.9	-17.7	-15.5	-13.3	-11.1	-8.9	-6.6	-4.4	-2.2	0.0	2.2	4.4	6.6	8.9	11.1	13.3	15.5	17.7	19.9	22.1
610.	-21.8	-19.6	-17.5	-15.3	-13.1	-10.9	-8.7	-6.6	-4.4	-2.2	0.0	2.2	4.4	6.5	8.7	10.9	13.1	15.3	17.5	19.6	21.8
620.	-21.5	-19.3	-17.2	-15.1	-12.9	-10.8	-8.6	-6.5	-4.3	-2.2	0.0	2.1	4.3	6.4	8.6	10.7	12.9	15.0	17.2	19.3	21.5
630.	-21.2	-19.0	-16.9	-14.8	-12.7	-10.6	-8.5	-6.4	-4.2	-2.1	0.0	2.1	4.2	6.3	8.5	10.6	12.7	14.8	16.9	19.0	21.2
640.	-20.8	-18.7	-16.6	-14.6	-12.5	-10.4	-8.3	-6.2	-4.2	-2.1	0.0	2.1	4.2	6.2	8.3	10.4	12.5	14.6	16.6	18.7	20.8
650.	-20.4	-18.4	-16.4	-14.3	-12.3	-10.2	-8.2	-6.1	-4.1	-2.0	0.0	2.0	4.1	6.1	8.2	10.2	12.3	14.3	16.3	18.4	20.4
660.	-20.1	-18.1	-16.1	-14.1	-12.0	-10.0	-8.0	-6.0	-4.0	-2.0	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.1	20.1
670.	-19.7	-17.7	-15.7	-13.8	-11.8	-9.8	-7.9	-5.9	-3.9	-2.0	0.0	2.0	3.9	5.9	7.9	9.8	11.8	13.8	15.7	17.7	19.7
680.	-19.3	-17.4	-15.4	-13.5	-11.6	-9.6	-7.7	-5.8	-3.9	-1.9	0.0	1.9	3.8	5.8	7.7	9.6	11.6	13.5	15.4	17.3	19.3
690.	-18.9	-17.0	-15.1	-13.2	-11.3	-9.4	-7.6	-5.7	-3.8	-1.9	0.0	1.9	3.8	5.7	7.5	9.4	11.3	13.2	15.1	17.0	18.9
700.	-18.4	-16.6	-14.8	-12.9	-11.1	-9.2	-7.4	-5.5	-3.7	-1.8	0.0	1.8	3.7	5.5	7.4	9.2	11.1	12.9	14.7	16.6	18.4
710.	-18.0	-16.2	-14.4	-12.6	-10.8	-9.0	-7.2	-5.4	-3.6	-1.8	0.0	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18.0
720.	-17.6	-15.8	-14.0	-12.3	-10.5	-8.8	-7.0	-5.3	-3.5	-1.8	0.0	1.7	3.5	5.3	7.0	8.8	10.5	12.3	14.0	15.8	17.5
730.	-17.1	-15.4	-13.7	-12.0	-10.3	-8.5	-6.8	-5.1	-3.4	-1.7	0.0	1.7	3.4	5.1	6.8	8.5	10.2	12.0	13.7	15.4	17.1
740.	-16.6	-15.0	-13.3	-11.6	-10.0	-8.3	-6.6	-5.0	-3.3	-1.7	0.0	1.7	3.3	5.0	6.6	8.3	10.0	11.6	13.3	14.9	16.6
750.	-16.1	-14.5	-12.9	-11.3	-9.7	-8.1	-6.5	-4.8	-3.2	-1.6	0.0	1.6	3.2	4.8	6.4	8.1	9.7	11.3	12.9	14.5	16.1
760.	-15.6	-14.1	-12.5	-10.9	-9.4	-7.8	-6.3	-4.7	-3.1	-1.6	0.0	1.6	3.1	4.7	6.2	7.8	9.4	10.9	12.5	14.0	15.6
770.	-15.1	-13.6	-12.1	-10.6	-9.1	-7.6	-6.0	-4.5	-3.0	-1.5	0.0	1.5	3.0	4.5	6.0	7.5	9.1	10.6	12.1	13.6	15.1
780.	-14.6	-13.1	-11.7	-10.2	-8.7	-7.3	-5.8	-4.4	-2.9	-1.5	0.0	1.5	2.9	4.4	5.8	7.3	8.7	10.2	11.7	13.1	14.6
790.	-14.0	-12.6	-11.2	-9.8	-8.4	-7.0	-5.6	-4.2	-2.8	-1.4	0.0	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0
800.	-13.5	-12.1	-10.8	-9.4	-8.1	-6.7	-5.4	-4.0	-2.7	-1.4	0.0	1.3	2.7	4.0	5.4	6.7	8.1	9.4	10.8	12.1	13.5
810.	-12.9	-11.6	-10.3	-9.0	-7.8	-6.5	-5.2	-3.9	-2.6	-1.3	0.0	1.3	2.6	3.9	5.2	6.4	7.7	9.0	10.3	11.6	12.9
820.	-12.3	-11.1	-9.9	-8.6	-7.4	-6.2	-4.9	-3.7	-2.5	-1.2	0.0	1.2	2.5	3.7	4.9	6.2	7.4	8.6	9.9	11.1	12.3
830.	-11.7	-10.6	-9.4	-8.2	-7.0	-5.9	-4.7	-3.5	-2.3	-1.2	0.0	1.2	2.3	3.5	4.7	5.9	7.0	8.2	9.4	10.6	11.7
840.	-11.1	-10.0	-8.9	-7.8	-6.7	-5.6	-4.5	-3.3	-2.2	-1.1	0.0	1.1	2.2	3.3	4.5	5.6	6.7	7.8	8.9	10.0	11.1
850.	-10.5	-9.5	-8.4	-7.4	-6.3	-5.3	-4.2	-3.2	-2.1	-1.1	0.0	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5
860.	-9.9	-8.9	-7.9	-6.9	-5.9	-4.9	-4.0	-3.0	-2.0	-1.0	0.0	1.0	2.0	3.0	4.0	4.9	5.9	6.9	7.9	8.9	9.9
870.	-9.2	-8.3	-7.4	-6.5	-5.5	-4.6	-3.7	-2.8	-1.8	-0.9	0.0	0.9	1.8	2.8	3.7	4.6	5.5	6.5	7.4	8.3	9.2
880.	-8.6	-7.7	-6.9	-6.0	-5.1	-4.3	-3.4	-2.6	-1.7	-0.9	0.0	0.9	1.7	2.6	3.4	4.3	5.1	6.0	6.8	7.7	8.6
890.	-7.9	-7.1	-6.3	-5.5	-4.7	-3.9	-3.2	-2.4	-1.6	-0.8	0.0	0.8	1.6	2.4	3.2	3.9	4.7	5.5	6.3	7.1	7.9
900.	-7.2	-6.5	-5.8	-5.0	-4.3	-3.6	-2.9	-2.2	-1.4	-0.7	0.0	0.7	1.4	2.2	2.9	3.6	4.3	5.0	5.8	6.5	7.2

14

Table 9 SR (9.5 g) correction for temperature

Temp. ↓ / Freeness →	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
100.	28.9	25.5	22.1	18.9	15.8	13.0	10.1	7.5	4.8	2.4	0.0	-2.3	-4.5	-6.6	-8.6	-10.6	-12.5	-14.3	-16.0	-17.7	-19.4
110.	31.2	27.5	23.8	20.4	17.1	14.0	10.9	8.1	5.2	2.6	0.0	-2.5	-4.8	-7.1	-9.3	-11.4	-13.4	-15.4	-17.3	-19.1	-20.9
120.	33.4	29.4	25.5	21.9	18.3	15.0	11.7	8.6	5.6	2.7	0.0	-2.6	-5.2	-7.6	-10.0	-12.2	-14.4	-16.5	-18.5	-20.5	-22.4
130.	35.5	31.3	27.2	23.3	19.5	16.0	12.5	9.2	5.9	2.9	0.0	-2.8	-5.5	-8.1	-10.6	-13.0	-15.3	-17.6	-19.7	-21.8	-23.8
140.	37.6	33.2	28.8	24.7	20.6	16.9	13.2	9.7	6.3	3.1	0.0	-3.0	-5.8	-8.6	-11.2	-13.8	-16.2	-18.6	-20.9	-23.1	-25.2
150.	39.7	35.0	30.3	26.0	21.7	17.8	13.9	10.3	6.6	3.3	0.0	-3.1	-6.1	-9.0	-11.8	-14.5	-17.1	-19.6	-22.0	-24.3	-26.6
160.	41.6	36.7	31.8	27.3	22.8	18.7	14.6	10.8	7.0	3.4	0.0	-3.3	-6.4	-9.5	-12.4	-15.2	-18.0	-20.6	-23.1	-25.6	-27.9
170.	43.6	38.4	33.3	28.6	23.8	19.6	15.3	11.3	7.3	3.6	0.0	-3.4	-6.7	-9.9	-13.0	-15.9	-18.8	-21.5	-24.2	-26.7	-29.2
180.	45.4	40.0	34.7	29.8	24.9	20.4	15.9	11.8	7.6	3.7	0.0	-3.6	-7.0	-10.3	-13.5	-16.6	-19.6	-22.4	-25.2	-27.9	-30.4
190.	47.2	41.6	36.0	30.9	25.8	21.2	16.6	12.2	7.9	3.9	0.0	-3.7	-7.3	-10.8	-14.1	-17.3	-20.3	-23.3	-26.2	-29.0	-31.6
200.	48.9	43.1	37.4	32.1	26.8	22.0	17.2	12.7	8.2	4.0	0.0	-3.9	-7.6	-11.1	-14.6	-17.9	-21.1	-24.2	-27.2	-30.0	-32.8
210.	50.6	44.6	38.6	33.2	27.7	22.7	17.7	13.1	8.5	4.1	0.0	-4.0	-7.8	-11.5	-15.1	-18.5	-21.8	-25.0	-28.1	-31.1	-33.9
220.	52.2	46.0	39.9	34.2	28.6	23.4	18.3	13.5	8.7	4.3	0.0	-4.1	-8.1	-11.9	-15.6	-19.1	-22.5	-25.8	-29.0	-32.0	-35.0
230.	53.8	47.4	41.1	35.2	29.4	24.1	18.9	13.9	9.0	4.4	0.0	-4.2	-8.3	-12.2	-16.0	-19.7	-23.2	-26.6	-29.8	-33.0	-36.0
240.	55.3	48.7	42.2	36.2	30.3	24.8	19.4	14.3	9.2	4.5	0.0	-4.4	-8.6	-12.6	-16.5	-20.2	-23.8	-27.3	-30.7	-33.9	-37.0
250.	56.7	50.0	43.3	37.2	31.0	25.5	19.9	14.7	9.5	4.6	0.0	-4.5	-8.8	-12.9	-16.9	-20.7	-24.4	-28.0	-31.5	-34.8	-38.0
260.	58.1	51.2	44.4	38.1	31.8	26.1	20.4	15.0	9.7	4.8	0.0	-4.6	-9.0	-13.2	-17.3	-21.3	-25.0	-28.7	-32.2	-35.6	-38.9
270.	59.4	52.4	45.4	39.0	32.5	26.7	20.8	15.4	9.9	4.9	0.0	-4.7	-9.2	-13.5	-17.7	-21.7	-25.6	-29.4	-33.0	-36.5	-39.8
280.	60.7	53.5	46.3	39.8	33.2	27.3	21.3	15.7	10.1	5.0	0.0	-4.8	-9.4	-13.8	-18.1	-22.2	-26.2	-30.0	-33.7	-37.2	-40.7
290.	61.9	54.6	47.3	40.6	33.9	27.8	21.7	16.0	10.3	5.1	0.0	-4.9	-9.6	-14.1	-18.4	-22.6	-26.7	-30.6	-34.4	-38.0	-41.5
300.	63.0	55.6	48.2	41.3	34.5	28.3	22.1	16.3	10.5	5.2	0.0	-5.0	-9.8	-14.4	-18.8	-23.1	-27.2	-31.2	-35.0	-38.7	-42.3
310.	64.2	56.6	49.0	42.1	35.1	28.8	22.5	16.6	10.7	5.3	0.0	-5.1	-9.9	-14.6	-19.1	-23.5	-27.7	-31.7	-35.6	-39.4	-43.0
320.	65.2	57.5	49.8	42.8	35.7	29.3	22.9	16.9	10.9	5.3	0.0	-5.2	-10.1	-14.9	-19.4	-23.9	-28.1	-32.2	-36.2	-40.0	-43.7
330.	66.2	58.4	50.6	43.4	36.3	29.7	23.2	17.1	11.1	5.4	0.0	-5.2	-10.2	-15.1	-19.7	-24.2	-28.5	-32.7	-36.8	-40.6	-44.4
340.	67.2	59.2	51.3	44.0	36.8	30.2	23.6	17.4	11.2	5.5	0.0	-5.3	-10.4	-15.3	-20.0	-24.6	-29.0	-33.2	-37.3	-41.2	-45.0
350.	68.1	60.0	52.0	44.6	37.3	30.6	23.9	17.6	11.4	5.6	0.0	-5.4	-10.5	-15.5	-20.3	-24.9	-29.3	-33.6	-37.8	-41.8	-45.6
360.	68.9	60.8	52.6	45.2	37.7	30.9	24.2	17.8	11.5	5.6	0.0	-5.4	-10.7	-15.7	-20.5	-25.2	-29.7	-34.0	-38.2	-42.3	-46.2
370.	70.8	62.4	54.1	46.4	38.7	31.8	24.8	18.3	11.8	5.8	0.0	-5.6	-11.0	-16.1	-21.1	-25.9	-30.5	-35.0	-39.3	-43.4	-47.5
380.	71.4	62.9	54.5	46.8	39.1	32.1	25.0	18.5	11.9	5.8	0.0	-5.6	-11.0	-16.3	-21.3	-26.1	-30.8	-35.3	-39.6	-43.8	-47.9
390.	71.9	63.4	54.9	47.1	39.4	32.3	25.2	18.6	12.0	5.9	0.0	-5.7	-11.1	-16.4	-21.4	-26.3	-31.0	-35.5	-39.9	-44.1	-48.2
400.	72.3	63.8	55.2	47.4	39.6	32.5	25.4	18.7	12.1	5.9	0.0	-5.7	-11.2	-16.5	-21.5	-26.5	-31.2	-35.7	-40.1	-44.4	-48.5
410.	72.6	64.1	55.5	47.6	39.8	32.6	25.5	18.8	12.1	6.0	0.0	-5.7	-11.2	-16.5	-21.6	-26.6	-31.3	-35.9	-40.3	-44.6	-48.7
420.	72.9	64.3	55.7	47.8	39.9	32.7	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.7	-26.7	-31.4	-36.0	-40.4	-44.7	-48.8
430.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-48.9
440.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-49.0
450.	73.0	64.4	55.8	47.9	40.0	32.8	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.8	-26.7	-31.5	-36.1	-40.5	-44.8	-48.9
460.	72.9	64.3	55.7	47.8	39.9	32.7	25.6	18.9	12.2	6.0	0.0	-5.8	-11.3	-16.6	-21.7	-26.7	-31.4	-36.0	-40.4	-44.7	-48.9
470.	72.6	64.1	55.5	47.6	39.8	32.6	25.5	18.8	12.1	6.0	0.0	-5.7	-11.2	-16.6	-21.6	-26.6	-31.3	-35.9	-40.3	-44.6	-48.7
480.	72.3	63.8	55.3	47.4	39.6	32.5	25.4	18.7	12.1	5.9	0.0	-5.7	-11.2	-16.5	-21.6	-26.5	-31.2	-35.7	-40.1	-44.4	-48.5
490.	71.9	63.4	54.9	47.2	39.4	32.3	25.2	18.6	12.0	5.9	0.0	-5.7	-11.1	-16.4	-21.4	-26.3	-31.0	-35.5	-39.9	-44.1	-48.2
500.	71.4	63.0	54.6	46.8	39.1	32.1	25.1	18.5	11.9	5.9	0.0	-5.6	-11.1	-16.3	-21.3	-26.1	-30.8	-35.3	-39.7	-43.9	-47.9
510.	70.6	62.3	54.0	46.3	38.7	31.7	24.8	18.3	11.8	5.8	0.0	-5.6	-10.9	-16.1	-21.1	-25.8	-30.5	-34.9	-39.2	-43.4	-47.4
520.	70.0	61.8	53.5	45.9	38.3	31.5	24.6	18.1	11.7	5.7	0.0	-5.5	-10.8	-16.0	-20.9	-25.6	-30.2	-34.6	-38.9	-43.0	-47.0
530.	69.4	61.2	53.0	45.5	38.0	31.2	24.3	18.0	11.6	5.7	0.0	-5.5	-10.7	-15.8	-20.7	-25.4	-29.9	-34.3	-38.5	-42.6	-46.5
540.	68.7	60.6	52.5	45.1	37.6	30.9	24.1	17.8	11.5	5.6	0.0	-5.4	-10.6	-15.7	-20.5	-25.2	-29.6	-34.0	-38.2	-42.2	-46.1
550.	68.0	60.0	52.0	44.6	37.3	30.6	23.9	17.6	11.4	5.6	0.0	-5.4	-10.5	-15.5	-20.3	-24.9	-29.3	-33.6	-37.8	-41.8	-45.6
560.	67.3	59.4	51.4	44.1	36.8	30.2	23.6	17.4	11.3	5.5	0.0	-5.3	-10.4	-15.3	-20.1	-24.6	-29.0	-33.3	-37.4	-41.3	-45.1
570.	66.5	58.7	50.8	43.6	36.4	29.9	23.3	17.2	11.1	5.5	0.0	-5.3	-10.3	-15.2	-19.8	-24.3	-28.7	-32.9	-36.9	-40.8	-44.6
580.	65.7	58.0	50.2	43.1	36.0	29.5	23.1	17.0	11.0	5.4	0.0	-5.2	-10.2	-15.0	-19.6	-24.1	-28.3	-32.5	-36.5	-40.3	-44.1
590.	64.9	57.2	49.6	42.5	35.5	29.1	22.8	16.8	10.8	5.3	0.0	-5.1	-10.0	-14.8	-19.3	-23.7	-28.0	-32.1	-36.0	-39.8	-43.5
600.	64.0	56.5	48.9	42.0	35.0	28.7	22.5	16.6	10.7	5.2	0.0	-5.1	-9.9	-14.6	-19.1	-23.4	-27.6	-31.6	-35.5	-39.3	-42.9
610.	63.1	55.6	48.2	41.4	34.5	28.3	22.1	16.3	10.5	5.2	0.0	-5.0	-9.8	-14.4	-18.8	-23.1	-27.2	-31.2	-35.0	-38.7	-42.3
620.	62.2	54.8	47.5	40.8	34.0	27.9	21.8	16.1	10.4	5.1	0.0	-4.9	-9.6	-14.2	-18.5	-22.7	-26.8	-30.7	-34.5	-38.2	-41.7
630.	61.2	54.0	46.7	40.1	33.5	27.5	21.5	15.8	10.2	5.0	0.0	-4.8	-9.5	-13.9	-18.2	-22.4	-26.4	-30.2	-34.0	-37.6	-41.0
640.	60.2	53.1	46.0	39.4	32.9	27.0	21.1	15.6	10.1	4.9	0.0	-4.8	-9.3	-13.7	-17.9	-22.0	-25.9	-29.7	-33.4	-36.9	-40.3
650.	59.1	52.1	45.2	38.8	32.4	26.5	20.7	15.3	9.9	4.8	0.0	-4.7	-9.2	-13.5	-17.6	-21.6	-25.5	-29.2	-32.8	-36.3	-39.6
660.	58.0	51.2	44.3	38.0	31.8	26.1	20.4	15.0	9.7	4.8	0.0	-4.6	-9.0	-13.2	-17.3	-21.2	-25.0	-28.7	-32.2	-35.6	-38.9
670.	56.9	50.2	43.5	37.3	31.1	25.6	20.0	14.7	9.5	4.7	0.0	-4.5	-8.8	-13.0	-17.0	-20.8	-24.5	-28.1	-31.6	-34.9	-38.2
680.	55.7	49.2	42.6	36.5	30.5	25.0	19.5	14.4	9.3	4.6	0.0	-4.4	-8.6	-12.7	-16.6	-20.4	-24.0	-27.5	-30.9	-34.2	-37.4
690.	54.5	48.1	41.7	35.8	29.9	24.5	19.1	14.1	9.1	4.5	0.0	-4.3	-8.4	-12.4	-16.3	-20.0	-23.5	-27.0	-30.3	-33.5	-36.6
700.	53.3	47.0	40.7	35.0	29.2	23.9	18.7	13.8	8.9	4.4	0.0	-4.2	-8.3	-12.2	-15.9	-19.5	-23.0	-26.3	-29.6	-32.7	-35.7
710.	52.0	45.9	39.8	34.1	28.5	23.4	18.3	13.5	8.7	4.3	0.0	-4.1	-8.1	-11.9	-15.5	-19.0	-22.4	-25.7	-28.9	-31.9	-34.9
720.	50.7	44.7	38.8	33.3	27.8	22.8	17.8	13.1	8.5	4.2	0.0	-4.0	-7.9	-11.6	-15.1	-18.6	-21.9	-25.1	-28.2	-31.1	-34.0
730.	49.4	43.6	37.7	32.4	27.0	22.2	17.3	12.8	8.3	4.0	0.0	-3.9	-7.7	-11.3	-14.7	-18.1	-21.3	-24.4	-27.4	-30.3	-33.1
740.	48.0	42.3	36.7	31.5	26.3	21.6	16.8	12.4	8.0	3.9	0.0	-3.8	-7.4	-10.9	-14.3	-17.6	-20.7	-23.7	-26.7	-29.5	-32.2
750.	46.6	41.1	35.6	30.6	25.5	20.9	16.3	12.1	7.8	3.8	0.0	-3.7	-7.2	-10.6	-13.9	-17.1	-20.1	-23.0	-25.9	-28.6	-31.3
760.	45.1	39.8	34.5	29.6	24.7	20.3	15.8	11.7	7.5	3.7	0.0	-3.6	-7.0	-10.3	-13.5	-16.5	-19.5	-22.3	-25.1	-27.7	-30.3
770.	43.7	38.5	33.3	28.6	23.9	19.6	15.3	11.3	7.3	3.6	0.0	-3.5	-6.8	-10.0	-13.0	-16.0	-18.8	-21.6	-24.2	-26.8	-29.3
780.	42.1	37.2	32.2	27.6	23.1	18.9	14.8	10.9	7.0	3.4	0.0	-3.3	-6.5	-9.6	-12.6	-15.4	-18.2	-20.8	-23.4	-25.9	-28.3
790.	40.6	35.8	31.0	26.6	22.2	18.2	14.2	10.5	6.8	3.3	0.0	-3.2	-6.3	-9.3	-12.1	-14.9	-17.5	-20.1	-22.5	-24.9	-27.2
800.	39.0	34.4	29.8	25.5	21.3	17.5	13.7	10.1	6.5	3.2	0.0	-3.1	-6.0	-8.9	-11.6	-14.3	-16.8	-19.3	-21.6	-23.9	-26.1
810.	37.3	32.9	28.5	24.5	20.4	16.8	13.1	9.7	6.2	3.1	0.0	-3.0	-5.8	-8.5	-11.1	-13.7	-16.1	-18.5	-20.7	-22.9	-25.0
820.	35.6	31.4	27.2	23.4	19.5	16.0	12.5	9.2	6.0	2.9	0.0	-2.8	-5.5	-8.1	-10.6	-13.1	-15.4	-17.6	-19.8	-21.9	-23.9
830.	33.9	29.9	25.9	22.3	18.6	15.2	11.9	8.8	5.7	2.8	0.0	-2.7	-5.3	-7.7	-10.1	-12.4	-14.6	-16.8	-18.8	-20.8	-22.8
840.	32.2	28.4	24.6	21.1	17.6	14.5	11.3	8.3	5.4	2.6	0.0	-2.5	-5.0	-7.3	-9.6	-11.8	-13.9	-15.9	-17.9	-19.8	-21.6
850.	30.4	26.8	23.2	19.9	16.6	13.7	10.7	7.9	5.1	2.5	0.0	-2.4	-4.7	-6.9	-9.1	-11.1	-13.1	-15.0	-16.9	-18.7	-20.4
860.	28.6	25.2	21.8	18.7	15.6	12.8	10.0	7.4	4.8	2.3	0.0	-2.3	-4.4	-6.5	-8.5	-10.4	-12.3	-14.1	-15.9	-17.5	-19.1
870.	26.7	23.5	20.4	17.5	14.6	12.0	9.4	6.9	4.5	2.2	0.0	-2.1	-4.1	-6.1	-8.0	-9.8	-11.5	-13.2	-14.8	-16.4	-17.9
880.	24.8	21.8	18.9	16.2	13.6	11.1	8.7	6.4	4.1	2.0	0.0	-2.0	-3.8	-5.6	-7.4	-9.1	-10.7	-12.2	-13.8	-15.2	-16.6
890.	22.8	20.1	17.4	15.0	12.5	10.2	8.0	5.9	3.8	1.9	0.0	-1.8	-3.5	-5.2	-6.8	-8.4	-9.8	-11.3	-12.7	-14.0	-15.3
900.	20.8	18.4	15.9	13.6	11.4	9.3	7.3	5.4	3.5	1.7	0.0	-1.6	-3.2	-4.7	-6.2	-7.6	-9.0	-10.3	-11.6	-12.8	-14.0

15

H_M = height of the middle section of SR chamber (cm)

K = permeability of the bed (cm^2)

K_1, K_2, K_3 = constants

L = fiber bed thickness (cm)

Q = volumetric flow rate of filtrate (cm^3/sec)

Q_T = volumetric flow rate of filtrate from the CSF chamber (cm^3/sec)

Q_1 = volumetric flow rate through the bottom orifice (cm^3/sec)

Q_{10} = volumetric flow rate of filtrate (cm^3/sec), at $t = t_1$

Q_2 = volumetric flow rate through the side orifice (cm^3/sec)

R = medium resistance (cm^{-1}) = filtration resistance of fibers (cm^{-1})

r = radius of the fluid surface at any fluid level in the middle section of SR chamber (cm)

R_f = specific filtration resistance of the fiber mat (cm/g)

R_s = filtration resistance of screen (cm^{-1})

r_2 = radius of the lower section of SR chamber (cm)

t_M = time required for the fluid level to drop from the top of the middle section to the top of the bottom section in SR chamber (sec)

t_T = time required for fluid level to reach the top of the middle section in SR chamber (sec)

t_1 = time necessary for flow through the side orifice to stop (sec)

V = volume of filtrate collected in time, t (cm^3)

V_B = volume of bottom region of SR chamber (cm^3)

V_c = volume of fluid between the bottom orifice and the side orifice (cm^3)

V_M = volume of middle region of SR chamber (cm^3)

V_o = initial volume of pulp slurry in drainage chamber (cm^3)

V_T = volume of fluid in the top region of SR chamber when 1000 mL are contained in the chamber (cm^3)

V_1 = volume filtrate collected in time, t_1 (cm^3)

$V_2 = V_T + V_M$ (cm^3)

W = mass per unit area of deposited fibers (g/cm^2)

ΔP = pressure drop across bed ($g/cm\text{-}sec^2$)

μ = viscosity of filtrate (g/cm-sec)

ρ = filtrate density (g/cm^3)

ACKNOWLEDGMENT

Portions of this work were used by one of the authors (PCS) as partial fulfillment of the requirements for the M.S. degree at The Institute of Paper Chemistry. The authors would like to thank Mr. John Walsh and Ms. Karen Boyd for stimulating discussions. The authors are grateful to Mr. James Biasca for his assistance in numerical computation and to Mr. Bruce Andrews for his help in measuring filtration resistance.

LITERATURE CITED

1. Clark, F. C., Technical Association Papers, 14: 207(1931).

2. Green, A. B., Paper Ind., 17: 164(1935-1936).

3. Clark, J.d'A., Tappi, 53: 1, 108(1970).

4. El-Hosseiny, F., and Yan, J. F., Pulp Paper Mag. Can., 81: 6, 61(1980).

5. Boyd, K., The Institute of Paper Chemistry, 1983, unpublished results.

6. Swodzinski, P. C., Mathematical models of CSF and SR freeness, A291 Report, The Institute of Paper Chemistry (1984).

7. Walsh, J., The Institute of Paper Chemistry, 1983, unpublished results.

8. Davis, D. S., and Simerl, L. E., Paper Trade J., 91: 58(1930).

9. Kehoe, R. D., Technical Association Papers, 20: 20(1937).

10. TAPPI TIS 018-8, 1983.

16

IPC TECHNICAL PAPER SERIES #172

AUTHOR		
TITLE Mathematical Models of Canadian Standard Freeness (CSF) & Shoffpen-Riegler Freeness (SR)		
DATE LOANED	BORROWER'S NAME	DATE RETURNED

IPC TECHNICAL PAPER SERIES #172

GEORGIA-PACIFIC
CORPORATION
ATLANTA, GEORGIA